Established by **BENJAMIN SILLIMAN** in 1818.

THE

AMERICAN JOURNAL OF SCIENCE.

EDITOR: EDWARD S. DANA.

ASSOCIATE EDITORS

PROFESSORS GEO. L. GOODALE, JOHN TROWBRIDGE, H. P. BOWDITCH AND W. G. FARLOW, OF CAMBRIDGE,

PROFESSORS H. A. NEWTON, O. C. MARSH, A. E. VERRILL AND H. S. WILLIAMS, OF NEW HAVEN,

PROFESSOR GEORGE F. BARKER, OF PHILADELPHIA.
PROFESSOR H. A. ROWLAND, OF BALTIMORE,
MR. J. S. DILLER, OF WASHINGTON.

FOURTH SERIES.

VOL. I—[WHOLE NUMBER, CLI.]

No. 1.—JANUARY, 1896.

WITH PLATE I.

NEW HAVEN, CONNECTICUT.

1896.

TUTTLE, MOREHOUSE & TAYLOR, PRINTERS, 125 TEMPLE STREET.

Published monthly. Six dollars per year (postage prepaid). $6.40 to foreign subscribers of countries in the Postal Union. Remittances should be made either by money orders, registered letters, or bank checks.

MINERALS.

Individual Specimens of rarest and choicest variety for collectors and museums.

Systematic Collections, comprising carefully arranged and accurately labelled type specimens of all common or important species, especially adapted for educational work, are sold at very low prices.

Special Collections, illustrating the various ores; the uses of minerals; their physical and chemical character, etc., etc.

Minerals for Laboratory and experimental purposes at lowest rates by the pound.

Detached Crystals in great variety and perfection for students and investigators.

Microscopical Mounts of exceeding beauty.

THE LARGEST AND MOST VARIED STOCK OF MINERALS IN THE WORLD—*not an idle boast, but an undisputed statement of fact, supported by repeated comparisons.*

Owing to the enormous stock accumulated, our facilities for furnishing mineralogical material of every kind and quality are unequalled. In no other establishment in the world are such a number and variety of rare and valuable specimens displayed for sale. Our collections for educational purposes are unexcelled for practical value, attractive appearance and low price.

Orders receive our prompt attention.

If you contemplate the purchase of a collection for college, school or pupil it will pay you to write us.

Illustrated Catalogue 128 pp., *containing complete price lists with description of collections, etc.; and all circulars free. Send for our last* "**Supplement**" *descriptive of recent important arrivals.*

SCIENTIFIC BOOKS, PAMPHLETS, PAPERS, PROCEEDINGS AND TRANSACTIONS OF SOCIETIES, JOURNALS, ETC.

An immense stock. *Catalogues are published in all branches of Natural and Physical Sciences, such as Geology, Mineralogy, Mining, Botany, Ethnology, Zoology, General Science, Microscopy, Physics, Electricity, Chemistry, Agriculture, Education, and Medicine* in all branches.

All American books in print furnished on order, and foreign books obtained within a few weeks.

We make a specialty of Papers published in the Proceedings and Transaction of Scientific Societies, and many of the scientific men of the country, recognizing the advantage of such an exchange, have placed copies of their papers in our hands for sale. With our ever-exchanging and constantly increasing stock, we can supply old and recent literature on all scientific subjects, and list of books and papers referring to special subjects will be furnished gratis on application.

Dr. A. E. FOOTE,

WARREN M. FOOTE, Manager.

1224-26-28 North Forty-First Street,

PHILADELPHIA, PA., U. S. A.

Established 1876.

THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. I.—*The Quarries in the Lava Beds at Meriden, Conn.*; by WILLIAM M. DAVIS.

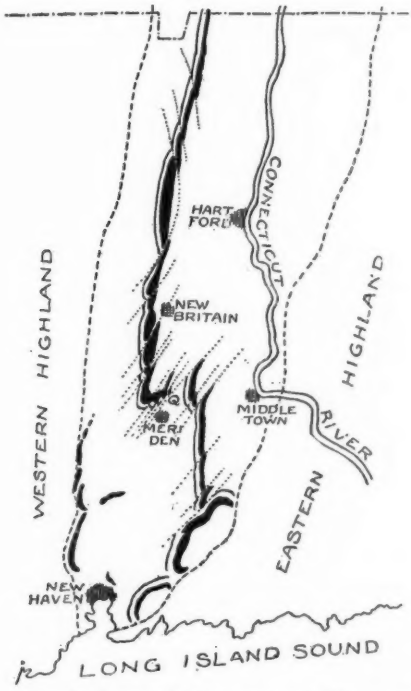
Summary.—Three quarries in the Triassic (Newark) formation near Meriden, showing the vesicular upper surface of one lava bed under the dense basal portion of a later flow, and a number of fractures dislocating the double flow. Relation of these features to the geological structure of the district.

THE present condition of the quarries in the trap ridge near Meriden, Conn., affords so fine an exhibition of the two lava beds of which the ridge is composed and of the fractures by which the beds are faulted, that the following account of their local and general relations is here placed on record.

The general location of the quarry ridge is a mile north of Meriden, at the point marked Q in the adjoining sketch map (fig. 1) of central Connecticut; broken lines indicating the boundary of the Triassic formation against the crystalline highlands on the east and west. It thus appears that the quarry ridge is topographically the smallest eastern member of the Hanging Hills group and therefore belongs to the long series of ridges that extends from Saltonstall or Pond ridge, close to Long Island sound east of New Haven, northward into Massachusetts as far as Mts. Tom and Holyoke. The interpretation of the structure of the district here advocated shows, further, that all these ridges are the outcropping edges of

a great extrusive lava sheet, once horizontal and continuous; now tilted, dislocated and denuded. Some of the dislocations of the region are indicated in fig. 1 by oblique dotted lines.

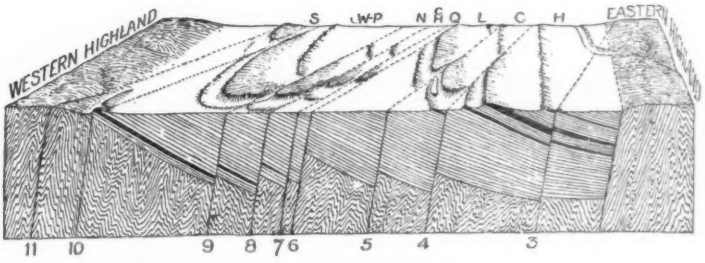
1.



The more local relations of the quarry ridge are exhibited in diagrammatic fashion in fig. 2, looking north. Here a piece of country, stretching from the western crystalline highland across the Triassic sandstones and the trap ridges, to the eastern highland, is roughly figured in perspective; the front face of the figure showing a vertical section of the faulted Triassic formation unconformably overlying an eroded foundation of crystallines. Much detail is omitted, and as is usual in the construction of generalized diagrams of this kind, a greater degree of definiteness and certainty is given at various points than would be allowed in a verbal statement. The structure of the crystalline rocks is wholly diagrammatic. The drawing nevertheless has a value in placing the reader quickly in possession of a number of important structural features. The

district is shown to be divided into "blocks" or "slabs," by a system of faults, here running obliquely with much regularity about northeast-southwest. Each block, whether wide or narrow, contains representatives of the normal sequence of sedimentary and igneous beds; the most important of the latter being the "main trap sheet,"—the greatest lava flow of the region—which always stands up as a dominating topographic element. The name locally given to the ridge formed in each block by the main sheet is here extended to the block itself; the initials of the name of each block standing over the northern margin of the diagram.* The faults are numbered

2.



beneath the diagram; two important faults occur southeast of the area here included, and the count therefore begins at "3." All the faults here shown, except the last one, have the upheaved side on the east, and hade steep to the downthrow, as far as determined. Two examples of small uplift on the west are known, one being number 11 and the other occurring a little north of the district here portrayed. In addition to the strong ridge of the heavy main sheet, there are in each block two smaller ridges, one in front of the outcropping face of the main ridge, the other behind its back slope; and hence called by Percival in his Survey of Connecticut some sixty years ago the *anterior* and *posterior* ridges. As all these ridges are but the topographic expressions of three extrusive lava sheets, the terms *anterior*, *main* and *posterior*, may be used in a chronological as well as a topographical sense. Near the left front margin of the diagram, the northern terminal members of the West Rock and Gaylord mountain range are seen; their whole length being indicated on fig. 1, north of New Haven. These ridges are formed on an intrusive trap sheet, apparently tilted, dislocated and denuded in the very manner that prevails with

* The initials on the upper margin of figure 2 are as follows: H., Higby; C., Chauncey; L., Lamentation; Q., Quarry; C. H., Cat-Hole; N., Notch; W. P., West Peak; S., Short.

the extrusive sheets; but in the present paper the intrusive sheet need not be further considered.*

It is manifest from figure 2 that the true stratigraphic sequence of the formation can be detected only by moving obliquely to the strike within the boundaries of a single "block;" but this is by no means manifest on the ground, for the fault lines by which the blocks are bounded cannot be seen except in rare instances and for very short distances. Hence it is important that the field evidence on which the existence of the faults is based should be carefully argued. An essential postulate in this argument is the extrusive origin of the three lava sheets, above mentioned: for extrusive sheets may, in spite of their igneous origin, be treated as if they were normal members of the stratified sedimentary series; and of all this series the lava sheets are of the greatest value in field work, on account of their strong outcrops. It is therefore of prime importance that the postulate as to the extrusive origin of the sheets should be carefully tested. Both these points,—extrusive origin of lava sheets, and existence of oblique faults, may be well studied in the Meriden district; and no single locality offers so large a variety of features for examination as the Quarry ridge in its present excellent condition of deep dissection. The district has become especially familiar to me on

* Some of my earlier articles seem to have given the impression that I regarded East Rock, New Haven, as belonging with the extrusive sheets of which Saltonstall and Totoket mountains are typical examples, and not with the intrusive sheets, of which West Rock and Gaylord's mountain are the type. Nothing has been further from my intention. My first summer's work on the Trias, in 1882, convinced me of the intrusive nature of East Rock, on the back slope of which "a very strongly baked granitic sandstone is found within a few feet of fine compact trap" (On the Relation of the Triassic Traps and Sandstones of the eastern United States, Bulletin Museum Comp. Zoöl., vii, 1883, 268.) Saltonstall ridge was regarded at the same time as an extrusive sheet, and contrasted with the intrusives, "such as East Rock and the Palisades" (ibid. 269). Specific account of the evidence on which the intrusive nature of East Rock was argued is given in the essay by Mr. Whittle and myself, entitled "The Intrusive and Extrusive Triassic Trap Sheets of the Connecticut Valley" (Bulletin M. C. Z., xvii, 1889, 105).

Another point in which my interpretations have been misunderstood concerns Mt. Carmel and the associated large dikes of the Blue Hills, southwest of Wallingford. I have been quoted as calling these dikes "buried volcanoes," but on the other hand I have regarded them as the underground necks of volcanoes from which some of the extrusive sheets were poured out. As such they are monuments of "lost volcanoes," but they are by no means "buried volcanoes." (See Bull. Geol. Soc. America, ii, 1891, 420–421; also, The Lost Volcanoes of Connecticut, Pop. Sci. Monthly, Dec., 1891, 226.) Having sometimes been taken to task for not considering the flows of Saltonstall, Totoket and the other ridges farther north to be intrusive sheets, it is now a little amusing to be called to account for not considering the undoubtable intrusive sill of the Palisades in New Jersey to be an extrusive sheet, and this on no other evidence than its great extent roughly conformable with the bedding. (See Lyman's recent Report on the "New Red" of Bucks and Montgomery Cos., Penna., in Final Report, 1895, iii, 2621.)

account of the use of it for a number of years past as one of the stopping places for a week or two of our summer course in geology: thus the ground has been carefully and repeatedly explored by teachers and scholars, and the explanations suggested to account for its structure have been subjected to close scrutiny. A brief account may be given of the evidence on which the extrusive origin of the three lava sheets rests.

In all three sheets, the upper surface is vesicular where exposed near the base of the back slope. This makes a striking contrast with the dense upper surface of the East Rock and West Rock sheets, and at once raises a strong presumption in favor of extrusion. Not satisfied, however, with this alone, careful search has been made for critical contacts and structures in the sheets of the separate blocks.

In the Higby block, the lower part of the anterior sheet consists in part of volcanic ash and lava blocks; at the upper surface of the sheet numerous detached fragments of vesicular trap have been found in the sandstone. The main sheet also is immediately overlain by a sandstone containing many fragments of vesicular trap. No evidence for the posterior sheet has been found.

In Chauncey block, the anterior sheet has a bed of ash and lava blocks at its base; and its upper vesicular surface is covered with sandstone containing many trap fragments, well shown when the reservoir was in process of construction in the anterior valley. A gulley on the back slope of the main sheet discloses an overlying stratum of sandstone holding amygdaloidal trap. A railroad cut at the southern end of the posterior sheet exhibits the usual "mixture" of vesicular trap fragments in the sandstone, as if a clinkery field of "*aa*"—in the Hawaiian sense—had been buried by a deposit of sand and mud: the fresh-cut rock here exposed several years ago frequently revealed minutely stratified sediments in the open vesicles of the trap, both in the loose fragments and in the back of the sheet itself; and the stratification of these little deposits was always parallel to that of the adjacent sandstones and shales.

In Lamentation block, the base of the anterior sheet contains the heavy bed of ash and lava blocks that has in recent years become well known to the people of Meriden, but unfortunately under the name of "the volcano." There is no evidence of any vent or local eruption to be found. The back of this sheet has the usual "mixture," and among the basal beds of the overlying sandstone there is a stratum of tuff-like nature. The back of the main sheet at its northern end is cut by Spruce brook so as to expose the sandstone where it filled the spaces among a confusion of vesicular fragments. The

posterior sheet does not here give decisive evidence of its origin.

The Quarry block will be described in detail below.

In Cat-hole block, the anterior sheet is opened in a small quarry near its base, where a ropy flow-structure is exposed. The vesicular upper surface of this sheet is well seen, but no actual contacts are found. The main and the posterior sheets in this block have afforded no evidence as to their manner of origin.

In Notch mountain block, a water-worn fragment of vesicular trap has been found in the sandstone about a foot above the very scoriaceous upper surface of the anterior sheet. The main and posterior sheets afford no evidence.

In West Peak and Short mountain blocks, no exposures of upper contacts have been found.

Other blocks north and south of the Meriden district afford repeated instances of "mixture" at the upper contact: for example in the gorge of Farmington river at Tariffville.* It should be understood, however, that while the lines of upper contact—sandstone on lava sheet—must measure many miles in total length, it is only here and there that they are exposed to sight, and then for but a few feet. To the geologist not familiar with these small but significant exposures, the sufficiency of the evidence of extrusion in the several blocks may be doubted, such is the prepossession in favor of "dikes" and "intrusions" when dealing with igneous rocks. The sufficiency of the evidence in one block to prove the extrusion of sheets in neighboring blocks, where no contacts are found, may be seriously questioned, so naturally is suspicion aroused when stratigraphic continuity is broken: but after repeated observation on the ground I believe that, taken altogether, the evidence of extrusion of the anterior, main, and posterior sheets is overwhelming and incontrovertible.

When the lava beds are once clearly recognized as extrusive, they may be used with any other members of the rock series in stratigraphic studies. The systematic repetition of the anterior, main, and posterior ridges in orderly succession over and over again, naturally suggests faulting: a line passing by the northern end of one set of the three ridges will, if continued to the southwest, pass by the southern end of the set in the next block: the lines of this kind also mark the termination on one side or the other of various minor ridges of sandstone on conglomerate: the same lines lead to the occasional

*See an article by Professor W. North Rice, this Journal, xxxii, 1886, 430–433. Also, The Intrusive and Extrusive Triassic Trap Sheets of the Connecticut Valley, by Davis and Whittle, in Bull. Museum Comp. Zoöl., xvi, 1889, 99–136.

changes of dip, these changes always departing from the rule of the monocline in such a way as to indicate a dragging pull from the neighboring fault: finally, it is upon these lines that occasional "dikes" of brecciated structure are found, agreeing in strike and dip with the expected attitude of normal fault planes. All these features occur so repeatedly and systematically that the faulting cannot be doubted for a moment when the facts become familiar. One after another of the ridges of lava, sandstone, or conglomerate that continue without interruption across a block will submissively end as they reach the invisible oblique line of a fault. Examples of this submission are so numerous and so systematic that the faulting of the blocks may be considered as conclusively proved as the extrusion of the lava beds.*

For those to whom it seems questionable to use lava beds as if they were sedimentary strata, a reassuring confirmation of the occurrence of faults may be found in the repetition of two beds of fossiliferous black shale, one in the anterior and the other in the posterior valley adjoining the ridges of the main lava sheet. Here the more customary stratigraphic argument for faulting, re-enforced by paleontological support, leads to the same conclusion as that already reached, but less definitely to my mind, for the beds of black shale are topographically weak, and are so seldom exposed that they prove only the occurrence but not the location of the faults by which they are dislocated.†

It is only when the facts and conclusions here briefly outlined are familiar that the Meriden quarries gain their full value. They are then seen to be not only serviceable as excel-

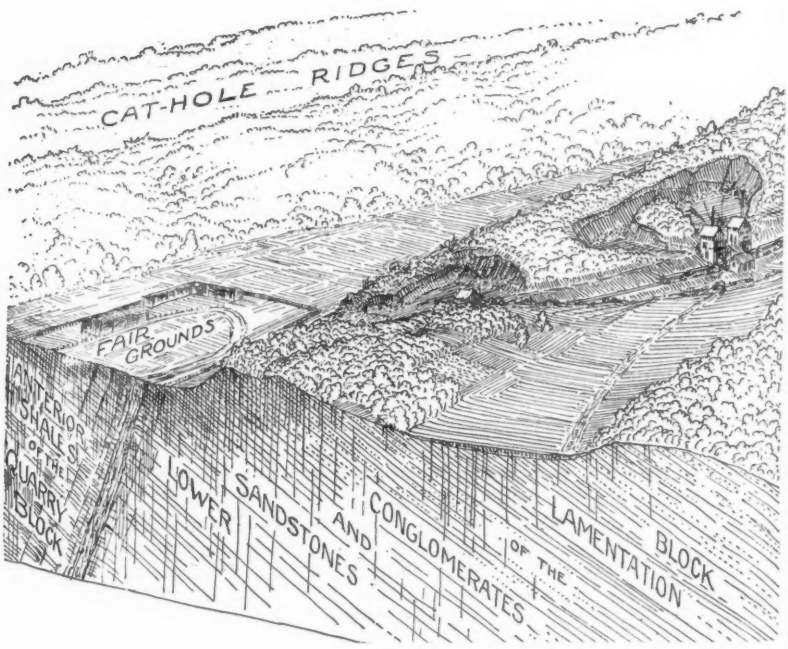
* Details concerning the faults in the Meriden district may be found in "The Faults in the Triassic Formation near Meriden, Connecticut." Bull. Mus. Comp. Zoöl., xvi, 1889, 61–86.

† Further details on this subject are given in "Two belts of fossiliferous black shale in the Triassic Formation of Connecticut," Davis and Loper, Bull. Geol. Soc. Amer., ii, 1891, 415–430.

It is well known that observations which are convincing to one geologist may not appeal forcibly to another. This was illustrated by an incident during the excursion made by many members of the International Geological Congress of 1891 from Washington to the West. On reaching Salt Lake, a recent fault along the base of the Wasatch mountains was argued from the visible topographic dislocation of the alluvial fans and glacial moraines at the foot of the range; but the European geologists of the party were so unaccustomed to arguments based on topographic form that with hardly an exception they refused to credit the conclusion as to recent faulting that had been reached by the geologists of our western surveys. It was only after repeated examples of faulted fans and moraines had been seen during two days of local excursions that a limited acceptance was allowed for what seemed to many of us as a very clear case. With this in mind, the evidence of faulting in the Connecticut Trias, as supplied by the ordinary stratigraphic and paleontological arguments from the black shales, has been a welcome addition to the evidence derived from the lava beds: not, however, so much for its effect on my own belief—for the argument based on the lava beds seems to me conclusive alone—as for the effect it might have on others to whom the lava beds may not seem to be altogether orthodox members of the sedimentary series.

lent local illustrations of faulted lava beds, but also as typical examples of structures on whose recognition the interpretation of the Triassic structure of the Connecticut valley depends. The locality has been a favorite with me for a number of years, always yielding new facts on repeated visits. During an excursion made in company with a number of geologists at the close of the meeting of the American Association in Springfield, September, 1895, the lesson of the quarries was found to be so much enlarged by their extension in the past three or four years, that I made another visit there a few weeks later just before the opening of our college year, so as to have leisure to examine them in detail. It is from notes taken on the latter visit that the following description is written.

3.



The quarries are opened in the southern quarter of a mile of the Quarry ridge, which extends thence northward for about a mile. The oldest quarry is at the end of the ridge; the others were opened in 1890. They are worked by Messrs. John S. Lane & Son, for railroad ballast and road metal; the rock being crushed alongside of a branch of the Consolidated

railroad, by which it is hauled away. Some 800,000 tons have been sold in the last five years. In the rough sketch here given, the lower and inner part of the quarries is occupied by what I shall call the lower bed: the upper and outer part by the upper bed. The surface of separation between the two beds may be traced without much difficulty; it is now very clearly shown at several places, but its distinctness varies with the condition of the quarry. Followed around the various faces of the quarry, this surface may be traced with more or less continuity for six or eight hundred feet; and if all loose stuff were cleaned away, a length of a thousand feet might probably be measured. I have attempted to show the contact in fig. 3 by a line that breaks the shading at the back of the quarries.

The deepest part of the lower flow now exposed is in the back of the southern one of the new quarries, where it is seen for about forty feet beneath its surface. Here it is of a bluish gray color, fine-grained and dense, rarely vesicular. Nearer its surface it becomes red or purplish, with an increasing proportion of vesicles. The red color does not seem to depend on the weathering of to-day, for it is fully developed deep in the quarries and in massive, unjointed rock: it should therefore be ascribed to weathering immediately subsequent to eruption, or to underground alteration. The color is often so strong near the upper surface that this part of the trap might easily be mistaken for baked sandstone. The largest regularly shaped vesicles in the upper part of the flow are nearly an inch in diameter; in the most vesicular rock the originally empty spaces must have occupied at least a third of the entire volume. Besides the spheroidal vesicles, now filled chiefly with calcite and chlorite, there are occasional irregular cavities, up to six inches in diameter, more or less completely filled with crystalline minerals, chiefly calcite. Mr. Chapman, foreman of the quarry, assured me that these contain water when first opened in fresh broken rock. With all these secondary minerals, however, this account has little to do.

The lower bed nowhere exhibits any distinct columnar structure, but has on the other hand a tendency to split into slabs four or five feet thick, along weathered joints parallel to its surface. The scoriaceous surface of the flow is occasionally stripped bare: thus at present there is, in the old quarry near its southern end, an area measuring about sixty by ten or fifteen feet, where its rolling form is well exposed. It is a typical example of the Hawaiian "pahoehoe." The adjacent swells of the surface measure three to six feet across, and their vertical relief may reach a foot or more.

The upper bed, as far as exposed in the quarries, is unlike the lower in many respects. The color of its deeper joint planes, where not affected by weathering, is dark steel-gray, greenish or bluish; the fresh broken rock is dark gray or greenish, without any of the bright reds or purples of the lower flow. The texture is dense throughout, vesicles and cavities being very unusual: but by following the quarry ridge to the northeast about a third of a mile, one may find the ordinary vesicular structure of the upper part of the bed there exposed on its back slope. The density of the upper bed in the quarry is particularly noticeable where it rests directly upon the rolling surface of the strongly colored and highly vesicular lower bed. At the point in the old quarry where the surface of the lower bed is best exposed, the dense, dark lava of the upper bed fits closely into all the inequalities, the two beds being sometimes so closely welded together that weathering has not loosened them along the surface of contact, and hand specimens can be broken off showing the two kinds of lava: but as a general rule a weathered seam or parting follows the contact. The columnar jointing of the upper bed is fairly well developed at many parts of the quarries, but it nowhere produces columns of notable regularity. Near the base of the upper bed, the rough joint columns are of small dimensions: half a foot to a foot in diameter. Some fifteen or twenty feet above the base the columns are often two, three or four feet in diameter. The weathered joints in the rocks near the surface of the ridge are yellowish in the upper bed, but brownish in the under bed. The former is hard enough for use as road metal to the very top of the quarry, but the latter is weak and rotten where it has been weathered. The stripping of the ridge in preparation for further quarrying exposes many well-glaciated rock surfaces.

The various original features of the two masses thus described accord so perfectly with what occurs in modern volcanic districts, and the secondary features result so naturally from the long lapse of time that the rocks have existed, that "a double-bedded lava-flow" seems to be a well warranted name for the whole structure. The most significant features of the structure appear over so large a quarry face, and maintain throughout so constant a relation that no reasonable doubt can remain as to their meaning. In order to enforce the general recognition of a conclusion so well supported, I have replaced the ordinary term "trap sheets" with the more suggestive term "lava beds," in the title of this article, and hope that the latter term may come into common use.

The absence of stratified deposits between the two lava beds may be variously explained. The first bed may have filled the

shallow waters of the estuary into which it flowed, so that its surface was exposed to the air; then before the gradual depression that long prevailed in the region succeeded in submerging the lava surface, the second bed may have been poured out on the first. If the top of the first bed did not reach the surface of the estuary waters, it must be supposed that the second flow occurred before a perceptible deposit of sediment had time to form. The probabilities seem in favor of the first supposition: for the close study that has been given to many good contact specimens by Mr. Whittle failed to detect any trace of stratified deposits between the two lavas: but on the other hand, a few grains of quartz were found, not derivable from the lava and perhaps best explained as wind-born sand.

The difficulty of recognizing the double structure of the "trap sheet" on the weathered, drift-covered, and wooded surface of the Quarry ridge prepares the observer not to expect manifest exhibition of double-bedded structure in the adjacent ridges of Cat-hole and Notch mountain blocks: but on the back of Notch mountain there are good indications that an upper flow occurs above the greater mass of the sheet.*

The lava beds no longer lie horizontal as they must have at the time of their extrusion, but dip to the east-southeast at an angle of fifteen or twenty degrees. This is shown by the slope of the vesicular portion of the under bed; the slope is so manifest that it is well known to the quarrymen. The sandstones of the district have a similar dip, thus confirming the idea that the lava beds were essentially level when they were poured out, and that they were afterwards tilted along with the whole mass of the formation. Indeed on this point there can be no doubt with regard to the extrusive sheets; but whether the intrusive sheets of West and East rocks, near New Haven, were driven between the sandstone beds before or after tilting is not definitely settled. The opinion that they were intruded after the tilting of the stratified beds is generally accepted; but the general accordance of their dislocations with those of the extrusive sheets in the Meriden district strongly suggests that both the intrusive and the extrusive sheets took their place in the bedded rocks before the tilting and faulting occurred.

The evidence of faulting, both on a small and a large scale, is remarkably distinct in the Meriden quarries and their immediate surroundings. Within the quarries there are several fissures, of breadth varying up to five or more feet, filled with fractured rock, now more or less weathered. The greater part

* Bulletin Museum Comp. Zoöl., xvii, 1889, 81.

of the filling is of trap fragments; but the space between the angular blocks of trap is generally filled with a matrix of sandstone or sandy shale; not fragments of bedded sandstone and shale, but a recomposed mass, presumably derived in the form of sandy or muddy powder from the grinding of overlying sandstones and shales at the time of faulting. All the ordinary features of fault structure may here be studied to good advantage.*

The amount of movement on the fault lines reaches fifteen or twenty feet in the best examples now exposed; this being on the little hill of rock left standing between the two northern quarries, where the vesicular surface of the lower lava bed is dropped by nearly twenty feet on the northwest side of the fault. This dislocation is very clearly exhibited at present. Several smaller examples of measurable throw occur in various parts of the quarries. The trend of the fractures varies from about north-northeast to northeast, the latter direction being that of a little swampy water course that obliquely terminates the quarry ridge on the south. The rock exposures nearest to this little valley are the weathered breccias on the margin of the southern quarry, and there is every reason to think that the valley itself is nothing but the topographic expression of a broad band of fractured rock, produced by a strong fault. The distribution of ledges and ridges in the neighborhood gives full support to this idea. Just across the little valley is the northern end of a ridge of conglomeratic sandstone, whose strike would carry its strata directly into the lava beds. Although the lavas were poured out previous to the deposition of the overlying fragmental beds and although the pebbles of the conglomeratic beds give evidence of rather active currents, no trap fragments are to be found among the pebbles; and this increases the presumption that the two masses—the lava beds and the conglomeratic sandstones—do not lie in their original relative positions, but have been brought into their present relation by faulting. Adopting provisionally the general course of the little valley as the trend of the dislocation separating the two dissimilar ridges, and walking northeast or southwest, abundant confirmation of this idea is found. The sandstone ridges, coming northward towards the line of the supposed fault, end on reaching it in the submissive manner already described; and at a distance of several miles to the northeast, the northern ends of the anterior, main and posterior sheets of the Lamentation block are similarly truncated. The uplift of the fault is then seen to be on the eastern side, and its movement approaches two thousand

* Details are given in the article on "The Faults in the Triassic Formation near Meriden," already referred to.

feet; this being the great fault of the region, numbered 6 on fig. 2. The entire structural arrangement of the district is soon found to accord with the clue suggested by the quarries; thus enhancing their value as a place for beginning the study of the region.

The best approach to the quarries is by an old road leading north from the highway just east of the Fair Grounds. The observer then follows the ridge of conglomeratic sandstone above referred to for a little distance before the quarry ridge comes in sight. With the expectation that a strong topographic feature would suggest, he naturally looks forward to the continuation of the ridge for some distance. Hence there is always an element of surprise when dark rocks in the old quarry first rise into view a few hundred feet to the north in line with the strike of the conglomerates. The chief problem of the region—the relation of the lava beds to the sedimentaries—is thus brought vividly to mind; and before returning from the quarries the problem may be advanced far toward solution.

Harvard University, October, 1895.

Art. II.—*Note on Globular Lightning;* by O. C. Marsh.

A great deal has been written recently on the various forms of lightning, and the subject itself has so much scientific interest, that it may be worth while to place on record an observation of my own on globular lightning, made years ago, in which the main facts are different from any I have seen described.

On Tuesday, July 23, 1878, I was on board a large yacht at anchor in the harbor of Southampton, England. About two o'clock in the afternoon, when we were about to sail, a violent thunder storm came up from the west, and as it passed over Southampton, several bolts descended, one of which, as I afterwards learned, struck a church. As the first drops of rain came down on the yacht, I was standing in the after companion way, looking forward, when my attention was attracted by a bright light apparently near the upper part of the foremast. When I first saw it distinctly, it was about half-mast high, and was falling slowly and directly toward the deck. This light was a ball of fire, a delicate rose-pink in color, pear-shaped in form, with the large end below, and appeared to be four or five inches in diameter and six or eight in length.

When it struck the deck, about forty feet from where I was standing, there was a loud explosion, and it was some minutes before it could be ascertained what damage had resulted. The mate, who was near the mainmast, about twenty-five feet from where I stood, was knocked down, but soon recovered. The same bolt, or part of it, also passed in front of the foremast, down a windsail ventilator, into the galley, where it knocked a large tin pan from the hands of a cook, and upset things generally in the culinary department, but injured no one seriously. Of the crew, some were on deck and some below, but none were really harmed, although a few were badly demoralized. A strong ozone-like odor was observed immediately after the explosion, and this remained perceptible for some time.

The officer in command of the yacht, Captain Matthews, who was forward at the time, and escaped without injury, stated that just after the stroke, he saw "streaks of lightning running around on deck like snakes." I was myself only dazed for a moment by the explosion, and saw distinctly that the deck forward was illuminated with a bright confused light. The owner of the yacht, George Peabody Russell, and his other guests, had gone below when the storm began, and suffered no harm, except possibly from fright, as they were still further away from the stroke.

As soon as the storm had passed, I made careful notes of the whole occurrence, with drawings and measurements, as I was much interested in the subject, and it was the first instance of the kind I had seen at close quarters. An inspection showed that the vessel itself had sustained no material damage, and not even permanent marks were left on the deck where the ball of fire exploded. A number of other yachts were at anchor quite near our vessel at the time, among them the white "Sunbeam" just home from her well-known voyage, but we saw no indications that any of these had been struck. I had no time to inquire, as immediately after the storm we sailed on a cruise to the eastward.*

Yale University, New Haven, Conn., December 4, 1895.

*Those interested in the rarer forms of lightning will find many observations recorded in "Nature," especially during the last fifteen years.

ART. III.—*The Form of Isolated Submarine Peaks;* by G. W. LITTLEHALES, U. S. Hydrographic Office.

THEORETICALLY the form of an isolated submarine peak would be that of a solid of revolution in which the crushing strength of any section is equal to the combined weight of the portion of the formation above that section and of the superincumbent body of water. Let y denote the radius of any section, and x its distance from the top of the formation. Let K denote the coëfficient of crushing strength of the material composing the formation; δ, the weight of a unit of its volume; and δ', the weight of a unit of volume of sea-water.

Assuming that the top of the formation just reaches to the surface of the ocean,

$\pi\delta\int y^2 dx$ = the weight of the formation above any section whose distance from the top is x,

$2\pi\delta'\int y.\,x.\,dy$ = the pressure of the water upon the formation above any section whose distance from the top is x,

$\pi K y^2$ = the strength of any section to resist crushing.

Then

$$\pi\delta\int y^2 dx + 2\pi\delta'\int y.\,x.\,dy = \pi K y^2 + C \qquad (1)$$

in which C is a constant representing the excess of crushing strength in any section above what is necessary to withstand the pressure caused by the weight of the formation and the weight of the superincumbent body of water.

By differentiation, equation (1) becomes

$$\pi\delta y^2.\,dx + 2\pi\delta' y.\,x.\,dy = 2\pi K\,.\,dy$$

or
$$\frac{\delta}{2}\,\frac{dx}{(K-\delta' x)} = \frac{dy}{y}$$

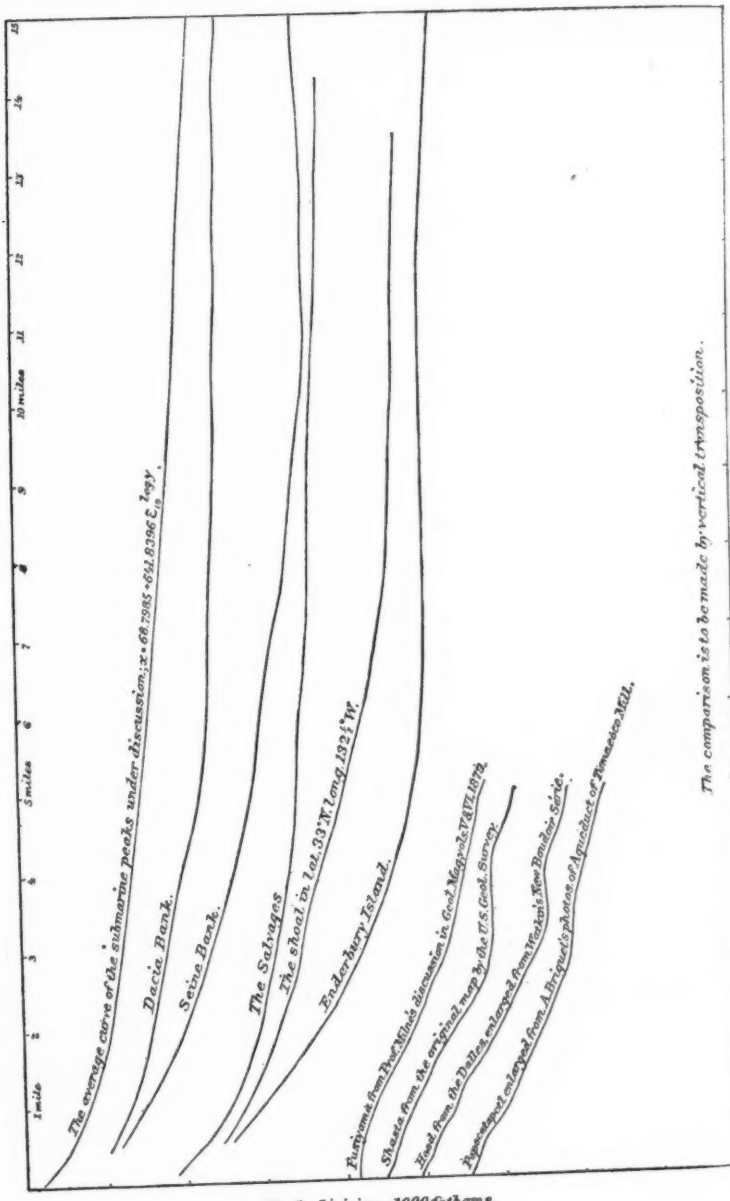
or
$$\frac{\delta}{2\delta'}\,\frac{dx}{\left(\frac{K}{\delta'}-x\right)} = \frac{dy}{y} \qquad (2)$$

By integration, equation (2) becomes

$$\frac{\delta}{2\delta'}\log\left(x-\frac{K}{\delta'}\right) = \log y$$

or
$$x = \frac{K}{\delta'} + \varepsilon^{\frac{2\delta'}{\delta}\log y} \qquad (3)$$

in which ε is the base of the Naperian system of logarithms.


1 mile
3 miles
10 miles
The average curve of the submarine peaks under discussion; $x = 68.7985 + 64l.8396\,\mathcal{L}_{10}\,\text{logy}$.
Dacie Bank.
Seiva Bank.
The Salvages
The shoal in Lat. 33° N. Long. 132½° W.
Enderbury Island.
Fortunate from Prof. Hind's discussion in Good Magazine, VII. 1872.
Sheats from the original map by the U.S. Geol. Survey.
Head from the Dalles, enlarged from Wetton's New Bonchain Serie.
Pyramidical, enlarged from A. Briquet's photos of Aqueduct of Pomaret, Mill.
The comparison is to be made by vertical transposition.
Each division = 1000 fathoms.

This equation has been used in the generalized form, $x = A + B\varepsilon^{\log y}$, to find from the observed bathymetric data in relation to Dacia Bank in latitude 31°–10′ N. and longitude 13°–40′ W., Seine Bank in latitude 33°–50′ N. and longitude 14°–20′ W., The Salvages in latitude 30°–05′ N. and longitude 15°–55′ W., Enderbury Island in latitude 3°–10′ S. and longitude 171°–10′ W., and the shoal in the North Pacific ocean in latitude 32°–55′ N. and longitude 132°–30′ W., the equation to their average form.

For this purpose the values of y, expressed in nautical miles, and x, in fathoms, were inserted in the above equation and a conditional equation was formed for each of the submarine formations. From these conditional equations normal equations were found by the Method of Least Squares, which gave the values of the constants A and B. The resulting equation is

$$x = +68{\cdot}7985 + 641{\cdot}8396\ \varepsilon^{\log y},$$

and the corresponding curve is shown in the accompanying diagram together with others which have been plotted from measured data for purposes of comparison.

This investigation has an important bearing upon the intervals at which deep-sea soundings should be taken in searching for probable shoals in the open ocean and in developing the character of the bottom of the sea. It shows that isolated formations occupying comparatively limited areas at the bottom can and do occur in deep water, and we are able to assign at once the maximum interval that should obtain between deep-sea soundings taken in the above-mentioned operations. The minimum radius at the bottom which a dangerous shoal can have must vary directly with the depth, but on the average, in the deep sea, it may be stated as 10 miles. An interval of 10 miles coupled with an interval of 2 miles would be sufficient for general development, and would prove with certainty the existence or absence of any formation rising close to the surface. Of all the possible ways in which a 10-mile interval could lie with reference to a submerged peak, that which would be most advantageous for a prompt discovery of its existence is the condition in which one end of the interval is at the bottom of the slope and the other near the apex, and that which would be least advantageous is the condition in which the interval is bisected by the position of the apex. In the latter case, there would be nearly equal soundings at both ends, but the soundings at the ends of the adjacent 2-mile intervals would immediately disclose the slopes.

DETROIT PUBLIC LIBRARY

ART. IV.—*On the Double Fluorides of Cæsium and Zirconium;* by H. L. WELLS and H. W. FOOTE.

IN connection with his comprehensive work on zirconofluorides, Marignac* has investigated the double fluorides of zirconium with ammonium, sodium and potassium, and since the corresponding cæsium salts have never been investigated, we have undertaken a study of them.

The following table gives Marignac's ammonium and potassium salts, together with those which we have prepared with cæsium:

3 : 1 Type.	2 : 1 Type.	1 : 1 Type.	2 : 3 Type.
$3NH_4F.ZrF_4$	$2NH_4F.ZrF_4$	----------	----------
$3KF.ZrF_4$	$2KF.ZrF_4$	$KF.ZrF_4.H_2O$	----------
----------	$2CsF.ZrF_4$	$CsF.ZrF_4.H_2O$	$2CsF.3ZrF_4.2H_2O$

The analogy between two types of cæsium and potassium salts is complete, while one type varies in each series. No evidence has been found that cæsium, in this case, forms a greater variety of compounds than potassium.

The symmetrical arrangement of the vacancies in the table, where no salts have been discovered, indicates that alkaline fluorides of lower molecular weight combine with a relatively smaller number of molecules of zirconium fluoride, while those of higher molecular weight combine with a greater number of such molecules.

The 2 : 1 type is the only one occurring in all three series. This is the common and usually the only type of double halogen salts formed by tetravalent elements, hence its occurrence in all cases was to be expected. The single sodium salt described by Marignac, $5NaF.2ZrF_4$, does not correspond to any of the compounds in the above table, but it is to be noticed that the composition corresponding to this formula varies but little from that required for $2NaF.ZrF_4$. Although Marignac's work on this salt was, as usual, very thorough and careful, it seems possible that his products may have been the 2 : 1 salt containing a small amount of some impurity, possibly a 3 : 1 compound.

Marignac described the salts $Mn_2ZrF_8.6H_2O$, $Cd_2ZrF_8.6H_2O$, $Zn_2ZrF_8.12H_2O$ and $Cu_2ZrF_8.12H_2O$, all of which correspond to a 4 : 1 type which has not been obtained with the alkali-metals. This type and those given in the preceding table make five varieties of zirconofluorides, one of which has been discovered in the present investigation.

* Ann. Chim. Phys., III, lx, 257.

The materials used for the preparation of the cæsium salts under consideration were carefully purified by ourselves. Hydrofluoric acid was made from perfectly pure fluor-spar and sulphuric acid, using a platinum still and redistilling the product. Cæsium carbonate, purified by the method described by one of us,* was used in preparing the fluoride. Zircon was used as the source of zirconium. The crude hydroxide was conveniently obtained by fusing the finely pulverized mineral with four parts of sodium carbonate, treating the resulting mass with hydrochloric acid, evaporating with an excess of sulphuric acid until the latter fumed, taking up with water, filtering and precipitating with ammonia. For purifying the zirconia, the method of Mitchell which has been advocated by Baskerville† was found convenient. This consists in dissolving the zirconium hydroxide in hydrochloric acid, nearly neutralizing with ammonia, adding a strong solution of sulphur dioxide and boiling. The precipitate, which, from the results of Venable and Baskerville,‡ appears to be a basic zirconium sulphite, can readily be washed free from iron.

The double salts were prepared by mixing solutions of the two fluorides in widely varying proportions, in the presence of more or less hydrofluoric acid, evaporating to the proper point and cooling.

When cæsium fluoride is in excess, even with very small amounts of zirconium fluoride, the salt $2CsF . ZrF_4$ is formed. It crystallizes in rather large, simple hexagonal plates, showing negative double refraction, and it can be recrystallized unchanged from water.

When a larger proportion of zirconium fluoride is used, the salt $CsF . ZrF_4 . H_2O$ is obtained. This forms monoclinic crystals elongated in the direction of the *b* axis, and with faces which are usually too rough for accurate measurement. This salt also can be recrystallized unchanged from water.

With a large excess of zirconium fluoride extremely small, difficultly soluble crystals of the salt $2CsF . 3ZrF_4 . 2H_2O$ are produced. The small crystals have a slight action upon polarized light, but their form could not be made out. It does not recrystallize from water in a pure condition, the product being mixed with the 1 : 1 salt.

To determine cæsium and zirconium, the fluorides were converted into sulphates, then zirconium was separated from cæsium by the use of ammonia, and zirconium oxide and cæsium sulphate were finally weighed. In order to determine fluorine a separate portion was dissolved in water, zirconium hydroxide was precipitated with ammonia, sodium carbonate

* This Journal, xlvi, 188. † Jour. Am. Chem. Soc., xvi, 475.
‡ Jour. Am. Chem. Soc., xvii, 448.

was added in slight excess to the filtrate and all the ammonia was removed by evaporation. To the hot solution calcium nitrate was added, and the resulting precipitate, after ignition, was cautiously treated with dilute formic acid until, after evaporation on the water-bath, a further addition of the acid produced no effervescence. The calcium fluoride finally remaining after a final evaporation was washed, ignited and weighed. The results of the fluorine determinations were invariably somewhat low.

The substitution of formic acid for the acetic acid usually used in removing calcium carbonate from the fluoride was suggested by the greater volatility of the first acid and the solubility of its calcium salt. We have found the modification to be an improvement as far as convenience is concerned, but we are not yet prepared to say that it is more accurate than the old method.

Water was determined by heating the substance in a boat behind a layer of dry sodium carbonate in a combustion-tube, and collecting and weighing it in a calcium chloride tube.

The following analyses of separate crops were made:

	$2CsF.ZrF_4$			
	A.	B.	C.	Calculated.
Cæsium	56·41	----	55·51	56·60
Zirconium	18·94	19·30	19·16	19·15
Fluorine	22·73	22·75	----	24·25
Water	1·63	0·98	0·97	

The small amount of water found in the analyses was evidently mechanically included, for, under the microscope, bubbles of mother-liquor could be occasionally seen within the crystals.

	$CsF.ZrF_4.H_2O$		
	A.	B.	Calculated.
Cæsium	----	38·44	39·58
Zirconium	27·19	27·11	26·79
Fluorine	27·24	27·52	28·27
Water	6·27	5·20	5·36

	$2CsF.3ZrF_4.2H_2O$		
	A.	B.	Calculated.
Cæsium	32·03	30·56	31·74
Zirconium	32·45	33·48	32·22
Fluorine	31·09	30·43	31·74
Water	4·40	3·96	4·30

Sheffield Scientific School,
New Haven, Conn., July, 1895.

Art. V.—*Section of the Cretaceous at El Paso, Texas;** by T. W. Stanton and T. Wayland Vaughan.

The detailed section of the Cretaceous of the Texas region here described is of interest because it is the most western of the outlying areas of the Texas Cretaceous as yet described, being 600 miles south of west from Denison, and 530 miles north of west from Austin.†

Although the details of the El Paso section have not hitherto been published, many references‡ have been made to it in the literature, and collections of fossils have been made there by Mr. R. T. Hill and Dr. E. A. Mearns, U. S. A. Mr. Hill's collection is at the Johns Hopkins University, and that of Dr. Mearns is deposited in the U. S. National Museum.

The section§ here described was made in Mexico and New Mexico near the Initial Monument of the Mexican Boundary Survey, about three miles west of the city. The lowest part of it is exposed in the cutting of the Southern Pacific railroad on the west bank of the Rio Grande, where it cuts the pass through the mountains. The section extends from here to the top of the hill across the arroyo southeast of the Initial Monument of the Boundary Survey. The rocks are greatly faulted, folded and disturbed by igneous intrusions, so to obtain the sequence and thickness of the beds it was necessary to establish horizons and measure between them where we could find them. Therefore, the highest beds of the section are not at the southeastern end of the exposures that we examined, but just north of a line joining the initial and second monuments of the Boundary Survey, where the rocks abut against a mass of hornblende porphyrite which is intruded through them. The downthrows of the faults are usually to the west.

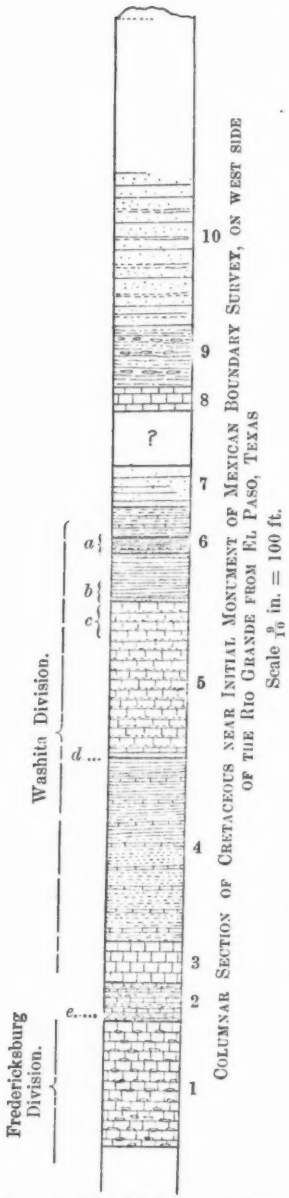
The following is a description of the section beginning with the highest bed:

* Published by permission of the Director of the U. S. Geological Survey.

† Gabb in vol. ii of the Paleontology, Geol. Survey of California, pp. 257–276, 1869, describes a collection of fossils made by Rémond from Sierra de las Conchas, near Arevichi, Sonora, Mexico. He recognized their resemblance to the Cretaceous fossils of Texas. Mr. R. T. Hill says concerning these fossils, in this Journal, vol. xlv, p. 313, April, 1893, "The fossils are the characteristic fauna of the latest or Washita division of the Comanche Series, and resemble the variations seen at El Paso and Juarez and throughout the northern littoral of the latest beds of the Comanche Series."

‡ R. T. Hill: Bull. Geol. Soc. of America, vol. ii, pp. 517 and 518, May, 1891; this Journal, vol. xlv, p. 312, April, 1893; Bull. Geol. Soc. America, vol. v, p. 332, March, 1894; this Journal, vol. l, p. 233, September, 1895. T. W. Stanton: In notes on a collection of fossils from near Belvidere, Kansas, published in R. T. Hill's "Outlying Areas of the Comanche Series in Kansas, Oklahoma, and New Mexico," this Journal, vol. l, p 218, Sept., 1895.

§ The description of the Denison Section published by R. T. Hill, Bull. Geol. Soc. of America, vol. v, pp. 303–304, and plate 13, March, 1894, should be consulted, while reading the description here presented.



10. Sandstone, white, yellow, or brownish, with shale beds ..... 200 ft.±
9. Clay shales, with bands of limestone nodules, containing great numbers of a large Exogyra ..... 40 ft.
8. Hard limestone with the same species of Exogyra in the top ..... 15 ft.
7. Sandstone, white or brown, 30 ft.+
6. Upper part of the bed, clay shales alternating with brown sandy flags.

   Brown sandy calcareous layers at base, containing *Gryphæa washitaensis* Hill and *Nodosaria texana* in great abundance.

   The *G. washitaensis* is confined to base. 30 ft. above the base, *Ostrea subovata. Ostrea quadriplicata* Shum. very abundant between 30 and 40 ft. 40 ft. above base zone of *Kingena wacoensis* ..... 60 ft.
5. Flaggy argillaceous limestone, with shale partings. Layer of sandy flags at base. In the sandy flags, *Cyprimeria.* In the limestone bands *Schlœnbachia leonensis, Gryphœa washitaensis, Protocardia, Trigonia emoryi.* The zone of *G. washitaensis* is at the top ..... 100 ft.
4. Clay shales, with indurated calcareous bands. No fossils were found ..... 125 ft.
3. Ledges of hard limestone. Fossils not numerous; at the base, there is a considerable number of an undetermined species of *Gryphæa, Gryphæa tucumcarii, Neithea,* and *Schlœnbachia* ..... 25 ft.

a. Kingena wacoensis, Ostrea quadriplicata, Ostrea subovata. b. Gryphæa washitaensis and *Nodosaria texana. c. Gryphæa washitaensis. d.* Sandy layer with *Cyprimeria. e.* Sandy layer.

2. Alternations of clay and soft argillaceous limestone ledges. Fossils: *Exogyra texana, Gryphæa tucumcarii, Gryphæa forniculata, Schlœnbachia peruviana,* 2 other species of *Schlœnbachia,* and a large *Neithea,* 24 ft.
1. Argillaceous limestone, in thick ledges, weathering into nodular limestone, the nodules surrounded by clay. Fossils: *Protocardia texana, Tylostoma pedernalis, Trochus, Turritella, Exogyra texana,* an Anchuroid genus, 2 sp. of Echinoids, *Pleuromya knowltoni, Requienia,* etc.
11 feet from the top *Ostrea subovata* (*?*) ..... 79 ft.

Total thickness ..... 698 ft. ±

The following is a list of species from the various beds:

No. 9 of Section.

Exogyra sp. A large species related to *E. ponderosa* Roemer.

No. 6 of Section.

Nodosaria texana Conrad.
Terebratula (Kingena) wacoensis Roemer.
Ostrea subovata Shumard. Typical examples of the species.
Ostrea quadriplicata Shumard.
Gryphæa washitaensis Hill.
Neithea texana (Roemer).
Gervilliopsis invaginata White?
Plicatula incongrua Conrad.
Modiola sp.
Trigonia emoryi Conrad.
Cardium (Protocardia) multistriatum Shumard?
Turritella sp. Related to *T. planilateris* Conrad.

No. 5 of Section.

Pyrina parryi Hall.
Enallaster texanus (Roemer).
Epiaster elegans (Shumard).
Gryphæa washitaensis Hill.
Neithea texana (Roemer).
Lima n. sp.
Lima wacoensis Roemer?
Modiola sp.
Cardium (Protocardia) texanum Conrad.
Turritella seriatim-granulata Roemer?
Aporrhais? —— Distinct from those in No. 1.
Natica?
Schlœnbachia leonensis (Conrad).

No. 3 of Section.

The fauna of No. 3 is essentially the same as that of No. 2, though the fossils are less numerous and not so well preserved. *Gryphœa forniculata* White, *Neithea texana* Roemer, *Schlœnbachia belknapi* Marcou, and a few other forms were recognized. No fossils were seen in No. 4.

No. 2 of Section.

Enallaster texanus (Roemer).
Holectypus planatus Roemer.
Gryphæa tucumcarii Marcou.
Gryphæa forniculata White.
Exogyra texana Roemer.—Most of the specimens belong to a rather robust variety described by Conrad under the name *Exogyra fragosa.*
Plicatula incongrua Conrad.
Neithea texana (Roemer).
Pinna comancheana Cragin.
Trigonia emoryi Conrad? Imperfect specimens that seem to be referable to this species.
Cardium (Protocardia) texanum Conrad.
Pholadomya sancti-sabæ (Roemer)?
Pleuromya knowltoni Hill?—Large specimens that probably belong to this species.
Tylostoma? sp.
Turritella seriatim-granulata Roemer?
Schlœnbachia peruviana von Buch.
Schlœnbachia belknapi Marcou.
Schlœnbachia sp.

No. 1 of Section.

Diplopodia texanum (Roemer).
Enallaster texanus (Roemer).
Ostrea subovata Shumard? A single specimen doubtfully referred to this species.
Exogyra texana Roemer.
Lima sp.
Neithea texana (Roemer).
Requienia texana (Roemer)? A large specimen probably of this species.
Cardium (Protocardia) texanum Conrad.
Pleuromya knowltoni Hill.
Neritina n. sp.
Tylostoma pedernalis (Roemer).
Turritella sp.
Aporrhais? Casts of two species.

Notes on the Fauna.

Taking the fauna of the section as a whole, its essential identity with that of the noted Tucumcari region in New Mexico and of other localities on the western and northern borders of the Lower Cretaceous area is at once apparent. The following list of species reported from Tucumcari is compiled by Mr. R. T. Hill in a recent paper:*

Turbinolia texana Conrad.
Ostrea marshi Sowerby (=O. subovata Shumard).
Ostrea quadriplicata Shumard.
Gryphæa dilatata, var. tucumcarii Marcou.
Gryphæa pitcheri Morton.
Exogyra texana Roemer.
Plicatula sp.
Neithea occidentalis Conrad.
Trigonia emoryi Conrad.
Protocardia multistriata (Shumard).
Protocardia texana Conrad.
Cytherea leonensis Conrad.
Pinna comancheana Cragin.
Cardita belviderensis Cragin.
Tapes belviderensis Cragin.
Roudairia (?) quadrans Cragin.
Cyprimeria sp.
Turritella seriatim-granulata Roemer.
Turritella marnochi White?
Ammonites leonensis Conrad.

These species, according to Mr. Hill, come from sandy and shaly beds below the supposed Dakota sandstone with a total thickness of 115 feet.

In the El Paso section, although there are one or two species that range from Nos. 1 to 6 inclusive, there are at least three well marked paleontological zones, each characterized by peculiar species that have been found useful as guide fossils in other parts of the Texan Lower Cretaceous area. Thus the fossils from No. 6 indicate a horizon in the upper part of the Washita corresponding to the Denison beds, that portion of the Washita in the Denison section that overlies the restricted Fort Worth limestone.

No. 5 contains *Schlœnbachia leonensis* and *Epiaster elegans*, which are regarded as the most characteristic species of the Fort Worth limestone.

* Outlying Areas of the Comanche Series in Kansas, Oklahoma and New Mexico, this Journal, III, vol. l, p. 230, Sept., 1895.

Nos. 1, 2 and 3 may be grouped together as the lowest of the three zones, which shows a commingling of fossils that elsewhere occur in the lowest Washita and in the Fredericksburg, with a few that range down into the Trinity division.

In north Texas the same species of Ammonites occur in the Kiamitia and Duck Creek (the Preston beds) at the base of the Washita and in the Goodland limestone, which belongs in the Fredericksburg. *Gryphæa forniculata* is a Kiamitia species. *Exogyra texana* is most abundant in the lower part of the Fredericksburg, though it ranges beyond both the lower and the upper limits of that division. The Echinoids also occur in both the Fredericksburg and the Washita. *Requienia texana*, *Pleuromya knowltoni* and *Tylostoma pedernalis* are other forms that suggest a lower horizon than the Washita.

The evidence of the fossils taken altogether is in favor of the view that a part of the Fredericksburg is represented here and that it grades into the basal Washita so imperceptibly that no palæontologic line can here be drawn between them. The Caprina limestone and its characteristic fauna, which in Central Texas, south of the Brazos river, usually affords such a distinct plane of separation, is absent here, as it is in north Texas and in all the outlying Lower Cretaceous areas of Kansas, Oklahoma and New Mexico.*

ART. VI.—*On the Epidote from Huntington, Mass., and the Optical Properties of Epidote;* by E. H. FORBES.

IN the fall of 1892, Mr. W. L. Angell of Huntington, Mass., brought several crystals to the Mineralogical Laboratory of the Sheffield Scientific School for determination. They resembled zoisite in color and general appearance, but upon examination proved to be epidote. Their light color and the absence of the usual green of epidote indicated a low iron percentage and suggested a chemical and optical investigation.

Abundant material was furnished by Mr. Angell, upon whose farm the mineral occurs, and some was also collected by Profs. S. L. Penfield and L. V. Pirsson, who visited the locality and found the epidote occurring in a seam in gneiss associated with quartz, biotite, albite and calcite. When the crystals project into cavities, they have a dark gray color and are clear and transparent, but when imbedded in the matrix they are much lighter in tone and less transparent, due undoubtedly to crushing, as the crystals are permeated by cracks and some are bent.

* See this Journal, September, 1895, p. 234.

Carefully selected crystals were taken for the analysis, which was made in duplicate according to the usual methods. The ferrous iron was determined as described by Pratt.* The results are given below, together with the specific gravity determinations, which were made upon a chemical balance:

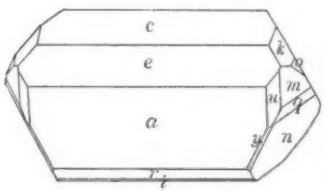
Specific gravity..	3·341	3·379	3·389	Average..3·367	
		Average.		Ratio.	
SiO_2	38·20	37·78	37·99	·633	6·00
Al_2O_3 ...	29·00	30·06	29·53 ·286	·321	3·04
Fe_2O_3 ...	5·63	5·71	5·67 ·035		
FeO	0·54	0·52	0·53 ·007		
MnO ...	0·21	0·21	0·21 ·003	·436	4·13
CaO	23·82	23·87	23·85 ·426		
H_2O	2·05	2·03	2·04	·113	1·07
Total ...	99·45	100·18	99·82		

The above ratios approximate closely to 6, 3, 4, 1, which, regarding the water as coming from hydroxyl, gives the usually accepted formula $H_2Ca_4Al_6Si_6O_{26}$ or $Ca_2(AlOH)Al_2Si_3O_{13}$, in which the calcium has been partly replaced by ferrous, and aluminium by ferric, iron. The analysis is interesting as showing a remarkably low iron percentage for epidote.

The crystals, as is common with epidotes, show a prismatic development parallel to the *b* axis and some of the largest ones measured over 30mm in length and 15mm in diameter. They are usually simple, but some are twinned parallel to 100.

Although the faces of the crystals were brilliant, yet the reflections of the signal on the goniometer were usually poor as the planes were commonly vicinal, which rendered the measurements somewhat uncertain. Some of the faces in the ortho-diagonal zone were deeply striated, so that there was a continuous series of reflections of the signal. Upon a suite of crystals which was measured, the following forms were identified:

a, 100	*u*, 210	*r*, $\bar{1}01$	*n*, $\bar{1}11$
c, 001	*e*, 101	*k*, 012	*q*, $\bar{2}21$
m, 110	*i*, $\bar{1}02$	*o*, 011	*y*, $\bar{2}11$



All of these were found upon a single crystal, as shown in the figure.

On the simpler crystals the forms *a*, *c*, *e*, *r* and *n* were prominent and developed about like fig. 5, page 517, 6th edition of Dana's Mineralogy.

* This Journal, xlviii, p. 149, 1894.

The following is a list of some of the measured angles compared with the calculated ones derived from the axes of N. von Kokscharow Jr.*

$$a : b : c = 1{\cdot}57874 : 1 : 1{\cdot}80362\ ;\ \beta = 64^\circ\ 36'\ 50''$$

		Measured.	Calculated.			Measured.	Calculated.
$c \wedge a$,	$001 \wedge 100 = 64^\circ\ 31'$		$64^\circ\ 36'\ 50''$	$c \wedge r$,	$001 \wedge \bar{1}01 = 63^\circ\ 31'$		$62^\circ\ 42'$
$a \wedge m$,	$100 \wedge 110 = 54\ 34$		$54\ 59\ 54$	$c \wedge k$,	$001 \wedge 012 = 38\ 29$		$39\ 10$
$c \wedge e$,	$001 \wedge 101 = 34\ 43$		$34\ 42\ 52$	$c \wedge m$,	$001 \wedge 110 = 75\ 4$		$75\ 45$
$c \wedge o$,	$001 \wedge 011 = 58\ 32$		$58\ 27\ 45$	$c \wedge n$,	$001 \wedge \bar{1}11 = 75\ 11$		$75\ 11$
$a \wedge e$,	$100 \wedge 101 = 29\ 48$		$29\ 54$	$c \wedge q$,	$001 \wedge \bar{2}21 = 89\ 32$		$89\ 42$
$c \wedge i$,	$001 \wedge \bar{1}02 = 34\ 00$		$34\ 21$				

Each of the above is the mean of at least three separate measurements, and their agreement is very satisfactory.

The optical investigations were made upon a single large crystal twinned about 100 and measured to make sure of the orientation. A section parallel to the clinopinacoid showed a slight zonal structure, and the central, or clearest portion, gave the following extinction: $a \wedge c$ red, Li = 1° 51′; yellow, Na, 2° 9′; green, Tl, 2° 12′, and for white light with the Bertrand ocular 2° 47′, all inclined to the c axis in the *obtuse* angle β. The extinctions were measured on either side of the twinning plane and the above are half of the recorded angles. The value with the Bertrand ocular is considerably higher than the others, due undoubtedly to the influence of the blue and violet of white light. The Untersulzbach epidote with about 14 per cent of Fe_2O_3, gives, according to Klein,† $a \wedge c$ for red 2° 56′ and for green, 2° 26′, but on the opposite side of the c axis, that is, in the *acute* angle β.

For the indices of refraction one prism was cut with a face parallel to 010 and its edge, as near as possible, parallel to the a axis, from which, by placing 010 perpendicular to the rays coming from the collimator, α for yellow, Na = 1·714 and γ = 1·724 were determined. By minimum deviation α was also found to be 1·714. By means of a second prism parallel to the b axis, β was found to be 1·716. As the crystal under examination had a zonal structure, the results have only a relative value, as they would be slightly different in another part of the crystal.

The low double refraction $\gamma - a = 0{\cdot}010$ is below that of any recorded epidote.

From plates cut at right angles to a and c the axial angles were determined by measuring in α-mono-bromnaphthalene (n, Na, = 1·6577) on a large Fuess axial-angle apparatus. From the plate at right angles to a, $2H_o = 94^\circ\ 33'$ for yellow Na, and from the second plate $2H_a = 93^\circ\ 25'$ were measured. From these values $2V_o = 90^\circ\ 32'$, $2V_a = 89^\circ\ 28'$ and β = 1·7144 were

* Materialen zur Mineralogie Russlands, viii, p. 44. † Jahrb. f. Min., 1874, p. 1.

obtained. In this crystal, a instead of being, as is usual, the acute becomes the *obtuse* bisectrix and the optical character is therefore positive.

The dispersion was distinctly inclined. In the section at right angles to c, the color to the right of each hyperbola was violet and to the left red, but they were more diffused in one than in the other. The dispersion $\rho < \upsilon$ was shown by the following measurements: $2H_a$ red, Li = 93° 10′, $2H_a$ yellow, Na = 93° 25′, $2H_a$ green, Tl = 93° 51′, but over the axis a the dispersion was $\rho > \upsilon$, as in other epidotes.

The pleochroism was quite striking, being in sections about 0·5^{mm} thick for rays vibrating parallel to b a lavender or pale plum-color, but parallel to a and c almost colorless, the former showing a slight tinge of lavender and the latter of green.

By a comparison of the analysis of the Huntington with those of other epidotes, it was found that the light-colored one from Zillerthal in Tyrol, analyzed by Laspeyres,* was almost identical in chemical composition, as shown by the following:

	SiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	CaO	H_2O	Insol.	Total
Huntington,	37·99	29·53	5·67	0·53	0·21	23·85	2·04	...	99·82
Zillerthal,	38·46	28·59	5·76	0·53	...	24·60	1·92	0·42	100·28

These analyses are, moreover, the lowest in iron percentages of any recorded epidotes. As no optical investigation of the crystals from Zillerthal has been published, one was made, for sake of comparison, upon a specimen in the Brush collection. The material used was a fragmentary crystal about 10^{mm} in diameter, decidedly zonal and of a pale red color on the exterior, but pale green in the interior. The crystallographic orientation was determined by measurement of the angle $100 \wedge 001$ and the cleavage parallel to 001. On a clinopinacoid section the extinction, measured with the Bertrand ocular, was found to be $a \wedge c = 0° 30'$ in the acute angle β for the interior green portion of the crystal, but for the exterior, or reddish part, it was about 0° 30′ in the obtuse angle β.

Prisms were cut, as in the Huntington mineral, with their edges in the inner green portion and the following indices of refraction determined: For yellow, Na, $\alpha = 1·720$, $\beta = 1·7245$, $\gamma = 1·7344$, $\gamma - \alpha = 0·0144$. From a plate parallel to 100 the value of $2H_o$, yellow Na, was found to be 96° 40′. (n, Na. for α-mono-bromnaphthalene being 1·6572) and from which 2Va, Na was found to be 87° 46′.

The pleochroism was very similar to that of the Huntington epidote. For sections about 0 5^{mm} thick b plum color, a and c alike and nearly colorless in the interior greenish part, while in the exterior reddish envelope a was pale green and c pale rose.

*Zeitschrift für Krystallographie und Mineralogie, iii, p. 562, 1879.

For further comparison an iron determination was made, with the following results: $Fe_2O_3 = 6{\cdot}97$, $FeO = {\cdot}89$ per cent, using as far as possible the green interior portion of the crystal, but owing to the scarcity of the material, some of the red part was also included. If only the green interior part had been used, these results would probably have been a trifle higher, but they are higher than those given by Laspeyres, whose analysis was made on carefully selected pale yellow crystals.

The following table, containing the results already given, together with the optical determinations on epidote from Untersulzbach in Tyrol by Klein,* will show the changes in the optical properties resulting from variations in the percentages of ferric iron:

Locality.	Fe_2O_3	Indices of refraction for yellow.				2Va, Na measured over a.
		α	β	γ	$\gamma-\alpha$	
Untersulzbach,	14·0	1·7305	1·7540	1·7677r	0·0372	73° 39′
Zillerthal,	6·97	1·720	1·7245	1·7344y	0·0144	87 46
Huntington,	5·67	1·714	1·716	1·724y	0·010	90 32

With a decrease in the percentage of iron, the indices of refraction and the strength of the double refraction decrease, while the axial angle measured over a increases, so that in the Huntington epidote c becomes the acute bisectrix and the crystal is positive with $\rho<\upsilon$ while most epidotes are negative with $\rho>\upsilon$.

In this connection the results of Ramsay† are of interest, who studied the zonal character of epidotes and determined the strength of the double refraction, $\gamma-\alpha$, in light and dark portions of crystals from different localities. He found that the light portions, containing presumably less iron than the dark, had the lowest double refraction, but gave no determinations as low as the ones given in this article for Zillerthal and Huntington. Some of his determinations are as follows:

Locality.	Dark. $\gamma-\alpha$.	Light. $\gamma-\alpha$.
Sulzbach	0·050	0·049
Zöptau	0·046	0·038
Arendal	0·054	0·050
Haddam	0·037	0·034
Brosso	0·023	0·017

In conclusion I wish to express my indebtedness to Prof. S. L. Penfield for valuable advice and assistance during the progress of this investigation.

Laboratory of Mineralogy and Petrography,
Sheffield Scientific School, June, 1895.

* Zeitschrift für Krystallographie und Mineralogie, iii, p. 562, 1879.
† Jahrb. f. Min., 1893, i, p. 111.

Art. VII.—*The Iodometric Determination of Selenious and Selenic Acids;* by F. A. Gooch and A. W. Peirce.

[Contributions from the Kent Chemical Laboratory of Yale College—XLVII.]

It has been shown in a recent paper from this laboratory* that the simple contact of solutions of selenious acid, potassium iodide, and hydrochloric acid according to the recommendation of Muthman and Schaefer† is not enough to effect the liberation of the theoretical amount of iodine when the assumption is made that the selenium of the selenious acid is all reduced to the elementary condition. On the other hand, it was found that the yield of iodine is complete when such mixtures are submitted to distillation under well-defined conditions. It is necessary, however, to estimate not only the iodine which passes to the distillate, but that which is retained in small proportion in the residue, and, though this method of proceeding yields closely accurate analytical results and is by no means difficult, it is obvious that a process so contrived that the reduction of the selenious acid should be registered entirely in the residue would possess the advantage in point of convenience. We have made the attempt, therefore, to apply in this case a principle of action laid down in a method elaborated in this laboratory for the estimation of chlorates.‡ When a solution of arsenic acid containing potassium iodide and sulphuric acid is boiled under defined conditions§ the arsenic acid is reduced to arsenious acid with liberation of iodine. When the arsenic acid is in excess the whole of the iodine is evolved and the arsenious acid produced is its exact measure. Upon making the solution alkaline with acid potassium carbonate, the arsenious acid may be re-oxidized by standard iodine, and the amount of iodine thus used will be the exact equivalent of that set free in the reduction-process. If, however, any other substance more easily reducible than arsenic acid is present, such substance should, naturally, take its part in liberating iodine from the iodide and the reduction of the arsenic acid should be correspondingly less. This was found to be the case when a mixture containing a chlorate, arsenic acid, potassium iodide, and sulphuric acid was boiled under regulated conditions, so that, with a knowledge of the amount of iodide employed and the determination of the quantity of

* Gooch and Reynolds, this Journal, I, 254.
† Ber. d. Chem. Gesell., xxvi, 1008.
‡ Gooch and Smith, this Journal, xlii, 220.
§ Gooch and Browning, this Journal, xxxix, 188.

iodine necessary to reoxidize the arsenious acid produced, the data were at hand for calculating the amount of chlorate present in the mixture. It was our hope (which proved to be well-founded, as the sequel shows) that selenious acid would behave like a chlorate under similar conditions.

Pure selenium dioxide was prepared by oxidizing presumably pure selenium in strong nitric acid, evaporating the solution to dryness, dissolving the residue in water, treating the solution with barium hydroxide until precipitation ceased, filtering, evaporating the filtrate to dryness, subliming the selenium dioxide from the residue, and resubliming that product in a current of dry oxygen (which we found to be vastly more convenient and effective than dry air) until it was perfectly white and crystalline. From the oxide thus made a standard aqueous solution was prepared, from which portions were measured and (for the sake of greater accuracy) weighed for use in the experiments to be detailed. To each weighed portion of the selenious acid, contained in an Erlenmeyer flask of 300 cm^3 capacity, was added a weighed amount of potassium iodide (somewhat in excess of that theoretically required) prepared in solution of convenient strength and tested as to its reducing power upon arsenic acid under the conditions of the experiments; a solution containing about 2 grm. of pure di-hydrogen potassium arseniate was introduced; and, finally, 20 cm^3 of sulphuric acid of half-strength. Protected from ordinary mechanical loss by a trap (consisting of a two-bulbed drying tube cut short and hung loosely with the wide end downward in the mouth of the flask) and from violent ebullition by the introduction of a few bits of porcelain, the liquid was boiled until the volume decreased according to indicating marks on the flask from 100 cm^3 or more to 35 cm^3—concentration to about this lower limit having been found to be necessary to the completion of the reaction. The residue was cooled, the acid was nearly neutralized with potassium hydroxide, acid potassium carbonate was added until it was present to the amount of 20 cm^3 of its saturated solution in excess of the quantity needed to complete neutralization, and, after the addition of starch, standard iodine was introduced until the starch-blue appeared. The iodine introduced measured the arsenious acid (and so the quantity of iodine set free by the arsenic acid), and the difference between it and the iodine originally present in the form of the iodide represents the amount set free by the selenious acid.

The following table comprises the details and results of a series of determinations made in the manner outlined:

Se = 79·1, O = 16

Initial volume. cm³.	Final volume. cm³.	H_2SO_4 half-strength. cm³.	Di-hydrogen-potassium arseniate. grm.	KI taken. grm.	SeO_2 taken. grm.	SeO_2 found. grm	Error. grm.
100	35	20	2	1·3277	0·1280	0·1275	0·0005—
"	"	"	"	1·0429	0·0998	0 0994	0·0004—
"	"	"	"	1·0887	0·1024	0·1028	0·0004+
"	"	"	"	1·0405	0·1036	0·1028	0·0008—
"	"	"	"	1·0721	0·1030	0·1029	0·0001—
"	"	"	"	0·9958	0·1273	0·1272	0 0001—
125	"	"	"	2·0828	0·1997	0·2000	0·0003+
"	"	"	"	2·2272	0·2110	0·2113	0·0003+
"	"	"	"	2·1535	0·2067	0·2069	0·0002+
150	40	"	"	2·6554	0·2560	0·2549	0·0011—
175	35	"	"	3·2428	0·3110	0·3118	0·0008+
"	35	"	"	3·2428	0·3085	0·3083	0·0002—

Obviously the reduction of selenious acid by this method is regular and accurate.

When similar treatment was applied to selenic acid it became apparent that the arsenic acid attacked and destroyed the iodide before the selenic acid had been completely reduced. It is plain, therefore, that the selenic acid must be reduced to the condition of selenious acid before its estimation by the iodide method can be attempted. Ordinarily the simplest mode of reducing selenic acid is by boiling it in solution with hydrochloric acid of definite strength,* but in this case the presence of hydrochloric acid is precluded on account of the consequent volatilization of arsenious chloride during the process of concentration in the subsequent treatment with the iodide. It has been shown, however, in a recent paper from this laboratory† that selenic acid is easily and completely reduced to selenious acid by potassium bromide and sulphuric acid under defined conditions. Moreover, arsenious bromide is not volatilized appreciably under the conditions. We made the attempt, therefore, to effect the iodometric determination of selenic acid by first reducing it to selenious acid by the bromide process and then treating the residue with arsenic acid and potassium iodide in the manner described.

Selenic acid was prepared in standard solution by treating a known weight of pure resublimed selenium dioxide by a strong solution of potassium permanganate, in presence of a moderate amount of sulphuric acid, until the purple color was distinctly visible, dissolving the precipitated oxide of manganese by oxalic acid, again adding permanganate until the final color of faintly visible pink was permanent for a half-hour or more, and diluting to a fixed volume. Portions of the solution of selenic acid were measured into counterpoised Erlenmeyer flasks of 300 cm³

* Gooch and Evans, this Journal, l. 400.
† Gooch and Scoville, this Journal, l. 402.

capacity and weighed, 1 grm. of potassium bromide was added, and sulphuric acid in such quantity that the total amount of the free acid should correspond to 20 cm³ of the acid of half-strength. The solution possessing a volume of 60 cm³ to 100 cm³ was boiled until the clear, colorless solution left when the bromine vanished began to color again. Experience showed that the reappearance of the brownish color is very easily seen and that it is not safe to conclude that all free bromine has been eliminated, under the conditions of dilution and proportion, until this stage of concentration—which corresponds to a volume of about 35 cm³—has been reached; but the distillation should not be pushed beyond the point at which the returning color is noted. When this condition was reached the solution was cooled, and treated exactly in the manner described for the reduction of selenious acid. The neutralization by acid potassium carbonate, after the final boiling, generally occasioned the precipitation of manganous carbonate, but the precipitate did not interfere in the slightest with the titration which followed.

The following table comprises the determinations which were made to test the accuracy of the iodometric determination of selenic acid by the combined processes of reduction.

SeO_2 taken as H_2SeO_4. grm.	KI used in second reduction. grm.	SeO_2 found. grm.	Error grm.
0·0378	0·6306	0·0380	0·0002 +
0·0378	0·5643	0·0374	0·0004 —
0·0516	0·7136	0·0517	0·0001 +
0·0503	0·7302	0·0508	0·0005 +
0·0541	0·6671	0·0544	0·0003 +
0·1007	1·3277	0·1011	0·0004 +
0·1008	1·3277	0·1011	0·0003 +
0·1007	1·2082	0·1005	0·0002 —
0·1007	1·1684	0·1016	0·0009 +
0·1007	1·0522	0·0999	0·0008 —
0·1009	1·2679	0·1005	0·0004 —
0·1031	1·1119	0·1032	0·0001 +
0·1870	1·8720	0·1879	0·0009 +
0·2014	1·9915	0·2020	0·0006 +
0·2016	2·0745	0·2025	0·0009 +
0·2059	1·8687	0·2064	0·0005 +

It is plain, therefore, that selenic acid may be determined iodometrically with accuracy by first reducing it to the condition of selenious acid by treatment with potassium bromide in presence of sulphuric acid, in the manner described, and then completing the reduction to the elementary condition by the treatment with potassium iodide and potassium arseniate.

Art. VIII.—*On the Interaction of Chromic and Arsenious Acids;* by Philip E. Browning.

[Contributions from the Kent Chemical Laboratory of Yale College—XLVIII.]

Kessler* has shown that arsenious acid may be determined by treating it, in the presence of hydrochloric acid, with an excess of a chromate solution of known strength, by which treatment the arsenious acid is oxidized and the chromic acid reduced. The excess of the chromic acid is then determined by the addition of a ferrous salt of known strength until a drop taken from the solution gives a blue color with a ferricyanide. Chromic acid is then added again until the blue color disappears. The amount of the chromate originally used less the excess determined by the ferrous salt gives the amount of the chromate used for the oxidation, from which may be calculated the amount of arsenious acid originally present. Despite the use of a ferrous salt and the numerous steps involved in the manipulation, Kessler claims very satisfactory results for his method. The object of this paper is to give the results of some experiments in which Kessler's reaction was used for the reverse process, the arsenious acid being used in excess, according to the reaction:

$$4CrO_3 + 3As_2O_3 + (X)As_2O_3 = 2Cr_2O_3 + 3As_2O_5 + (X)As_2O_3$$

For the work, a solution of potassium dichromate was made, the standard of which was determined by evaporating definite portions measured from a burette into previously weighed and counterpoised crucibles, heating just to the melting point, and weighing after cooling. A decinormal solution of arsenious acid was made in the usual manner, as was also a decinormal iodine solution which was standardized frequently in course of the work against the arsenious acid. The method of manipulation was as follows: Definite portions of the chromate solution were measured from a burette into counterpoised flasks and weighed, as a check on the burette reading, about 10 cm³ of dilute hydrochloric or sulphuric acid (1–4) added, and a carefully measured amount of the arsenious acid solution—care being taken to have an excess of the amount necessary for the reaction. After a few moments the reduction seemed complete, the solution having taken on the bluish green color characteristic of the chromium salts. The application of heat was found to be unnecessary, the reaction going on quickly

* Pogg. Anal., xcv, 204, 1855.

and completely, as it seemed, in the cold. The solution was then treated with acid potassium or sodium carbonate (about 5 grm.) in excess. At this point a precipitate formed unless Rochelle salts had been added, as was sometimes the case, to prevent it. To the alkaline solution iodine was added until a yellow tinge showed it to be in excess, and the solution was allowed to stand, with frequent shaking, about one-half hour, at the end of which time the excess of the arsenious acid was thoroughly acted upon. In order to test the permanency of the iodine color in alkaline solution, two experiments were made, in the first of which 5 grm. of acid sodium carbonate were dissolved in about 100 cm^3 of water, and in the second the amount of acid generally used (10 cm^3) was neutralized with the acid carbonate and an excess added, the amount of water present being about the same as in the first experiment. Starch and a drop of iodine solution were then added. No bleaching effect was apparent during two hours. Several experiments, made without allowing the solution to stand, with the excess of iodine seemed to show that the excess of the arsenious acid had not been completely oxidized by the iodine. As this took place mainly in those experiments in which the precipitate had not been held up by Rochelle salts, I am inclined to attribute it to the holding of the arsenious acid by the precipitate. After this point in the process had been reached, the excess of iodine was destroyed by the addition of arsenious acid, starch was added and the blue color obtained with iodine. Knowing the amount of arsenious acid originally added together with the second amount, used to bleach the excess of iodine, also the total amount of iodine employed and its value in terms of arsenious acid, we are in position to determine the amount of arsenious acid used for the reduction; and, by referring to the reaction given above we can calculate the amount of chromic acid originally present. The use of Rochelle salts had a disadvantage, however, which should be mentioned. If the precipitate is held up, the solution takes on a dark green color which makes the starch iodide reaction difficult to detect. The presence of the precipitate, except for the apparent holding of some arsenious acid—a source of error which seems to be largely obviated by the standing with the excess of iodine—causes no inconvenience, being itself of a very light green color and leaving the solution almost colorless. I have tried filtering with no gain in convenience, since the precipitate is of a gelatinous character and filters very slowly, so that the filtration and thorough washing lengthen the process very materially.

The results follow in the table:

	CrO_2 taken. grm.	CrO_3 found. grm.	Error. grm.	Remarks.
1	0·1001	0·1004	0·0003 +	
2	0·1005	0·1004	0·0001 —	The iodine acted 20 minutes
3	0·1006	0·1007	0·0001 +	" " "
4	0·1004	0·1011	0·0007 +	" " "
5	0·1009	0·1009	0·0000	" " 2 hours
6	0·1002	0·1003	0·0001 +	" " "
7	0·1011	0·1004	0·0007	Rochelle salts used
8	0·1007	0·1007	0·0000	" "
9	0·0401	0·0395	0·0006 —	
10	0·0402	0·0388	0·0014 —	0·5 grm. ferric alum present
11	0·1001	0·1018	0·1017 +	
12	0·1009	0·1007	0·0002 —	
13	0·1007	0·1011	0·0004 +	1 grm. ferric alum present
14	0·1005	0·1017	0·0012 +	
15	0·1004	0·1010	0·0006 +	
16	0·1000	0·1032	0·0032 +	Rochelle salts used
17	0·1005	0·1006	0·0001 +	1 grm. ferric alum present.

In three of the above experiments the process was carried through in the presence of a ferric salt with fairly successful results. The presence of the brown precipitate, however, makes the end reaction rather difficult to determine. If, however, the precipitate be allowed to settle after each addition of iodine, the color can be detected very readily in the supernatant liquid.

Among volumetric processes of great delicacy this process naturally does not find its place. It is, however, interesting to know to what degree the reaction may be depended upon for analytical purposes.

ART. IX. — *Note on the Analysis of Contrast-Colors by viewing, through a reflecting tube, a graded series of gray discs, or rings, on colored surfaces;* by ALFRED M. MAYER.

PROFESSOR ROOD in his "Modern Chromatics" (N. Y., 1879), p. 185, *et seq.*, describes a series of experiments he made on the change which a color undergoes when darkened. He gives a table of results on seventeen colors. These colors were obtained as intense, saturated and brilliant as possible and were painted on discs of card-board. Each of these discs was placed on the rotator in combination with a disc of black, so that the color could be gradually darkened by exposing more and more of the black disc on the surface of the colored one. He found that the effect of mixing black with some of these colors was merely to darken them. The effect of mixing black with others of the colors was not merely to darken these colors but also to change their hues.

On page 261 of "Modern Chromatics," Rood writes: "By preparing with Indian ink a series of slips of gray paper, ranging from pure white to black, an interesting series of observations can be made on the conditions most favorable for the production of strong contrast-colors. The strongest contrast will be produced in the case of red, orange and yellow, when the gray slip is a little darker than the color on which it is placed, the reverse being true of green, blue, violet and purple; in every case the contrast is weaker if the gray slip is much lighter or much darker than the ground."

The particular gray which gives the strongest contrast-color effect on a given colored ground can only be determined experimentally by observing a graded series of gray surfaces placed on the colored ground. In this manner I obtained the grays used in "Studies of the Phenomena of Simultaneous Contrast-color," etc., this Journal, July, 1893. These grays, however, were not selected by the unaided eye but by viewing the gray surfaces through my reflecting tube, which doubles the saturation and brilliancy of the contrast-color.* This increase in the saturation and brilliancy of the contrast-color renders the selection of the proper gray easy and definite.

The fact that the mixing of black optically with a color either merely darkens it, or changes its hue at the same time it darkens it, taken in connection with the fact that different depths of gray are required to give the maximum contrast-color effect on different colored surfaces, seems to me to offer,

* This Journal, July, 1893, p. 7 et seq.

in certain cases, a means of analyzing a composite contrast-color. Suppose that a small gray disc, or ring, when placed on a colored ground gives a contrast-color which is composite, like purple, and that the same depth of gray gives the maximum contrast-color effect for each component color of the purple; then, as we view in succession the gray discs of a graded series, the contrast-color of these discs should merely become darker and darker, as each component of the contrast-color is similarly affected as we view darker and darker grays. This, to my vision, is the case when the graded gray discs are viewed on a pure green ground. But if the maximum contrast-color effect for one of the component colors is given by a gray differing much in depth from the gray giving the maximum contrast-color effect for the other component, then the contrast-color should change both in its darkness and in its hue as we view in succession the darker and darker grays on the colored ground. This is what takes place in the case of viewing the graded series of gray discs on a violet ground; where the greenish-yellow given by the lighter shades of gray, become yellowish-green on viewing discs of deeper gray: the yellow component diminishing and the green component increasing till we reach a gray containing 80 per cent of black.

The experiments on which the foregoing statements are founded were made as follows: A series of grays were selected varying in depth from No. 1, containing 25 per cent of black to No. 15, containing 95 per cent of black. From these gray papers were cut discs of 1^{cm} in diameter which were pasted in order, from 1 to 15, on seven different colored surfaces. These discs were viewed, in succession, through a reflecting glass tube, having an interior diameter of $1{\cdot}9^{cm}$ and a length of $15{\cdot}5^{cm}$. This tube is coated on its outside surface with black Japan-varnish, which coating does away with the reflection from the outside surface of the tube and leaves alone the brilliant reflection from the interior surface. If a gray disc is placed on a colored ground and viewed through this tube it appears surrounded by two contrast-color rings produced by the reflection of the gray disc from the interior surface of the tube. These rings appear to have about double the saturation and brilliancy of color of the gray disc as seen without the aid of the reflecting tube.

Viewing the fifteen gray discs on a green ground* the contrast color given to the discs is purple, or a mixture of red and violet-blue. As you view, in order of their number, the

*The colored grounds used in these experiments were the colored papers of Milton Bradley Co., Springfield, Mass.

gray discs, there is, to my vision, no decided change in hue, but only a deeper shading of the purple as you view deeper and deeper grays. Now the maximum red of the purple contrast-color is given by gray No. 8 on a cyan-blue ground, while the maximum violet-blue of the purple is given by disc No. 8 on a yellow ground, therefore the hue of each component is equally affected, as the purple is mixed with more and more black. To test further whether the darkening of the purple causes a change in its hue, I obtained on the rotator a purple similar to that seen by viewing disc No. 5 on the green ground, and changed its illumination by rotating the plane of the discs, on the rotator, away from the incident light. I also darkened the purple by adding black on the rotator. In neither experiment, to my vision, did the purple change its hue; it was only darkened.

Viewing in succession the gray discs on a violet surface, numbers 1, 2, 3 and 4 appear greenish-yellow. No. 5 appears as much green as yellow; No. 6 appears yellowish-green. The following discs in order of their number appear greener and greener till No. 13 appears of a dark green almost devoid of yellow. Here you have an analysis of the contrast-color by viewing through the reflecting tube the gray discs on a violet ground, for the maximum contrast-color of the yellow component of the greenish-yellow is given by disc No. 4 on a blue ground, while the maximum contrast-color of the green component is given by disc No. 11 on a purple ground.

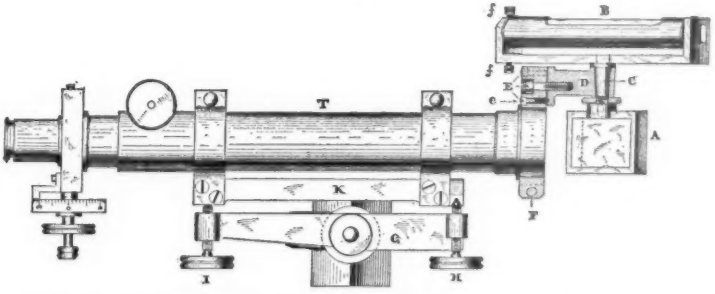
In this matter of color perception the personality of the observer enters as a very important factor; especially when the observer has reached an age when he knows that his color sense must be somewhat deadened and he does not know how much remains of the good perception of color which he once possessed. I therefore do not hesitate to say that I may be somewhat in error in my observations and in the deductions made from them. It may be that the whole matter of this note will turn out to be nothing more than the effect of mixing a color with black, as in Rood's experiments; though to my vision this is not so.

Art. X.—*A Very Simple and Accurate Cathetometer;* by F. L. O. Wadsworth. (With Plate I.)

Of the various standard physical instruments which are usually found in a student's laboratory, the cathetometer may justly be considered as one of the most instructive and valuable, both because of the many principles involved in its adjustment, and because of the number of measurements which may be made with it. Unfortunately good cathetometers (and it is never good policy to use poor instruments for the purposes of instruction), are so expensive, as made at present, that one or at most two are all that one laboratory can afford. For this reason it may perhaps be of interest to briefly describe a form of cathetometer recently designed by the writer which costs less than one-tenth as much as the best German or English instruments, but which has shown itself in use to be quite as accurate and in some respects even more convenient of manipulation than the latter.

In the new arrangement, the general method of comparison, now employed in nearly all of the most accurate linear measurements, is followed: i. e., the images of the observed points and of the lines on a standard bar, placed parallel with the length to be measured, are brought in succession into the field of an observing telescope or microscope, and their relative position determined by means of a micrometer or some equivalent arrangement. In previous forms of cathetometer this has been

1.

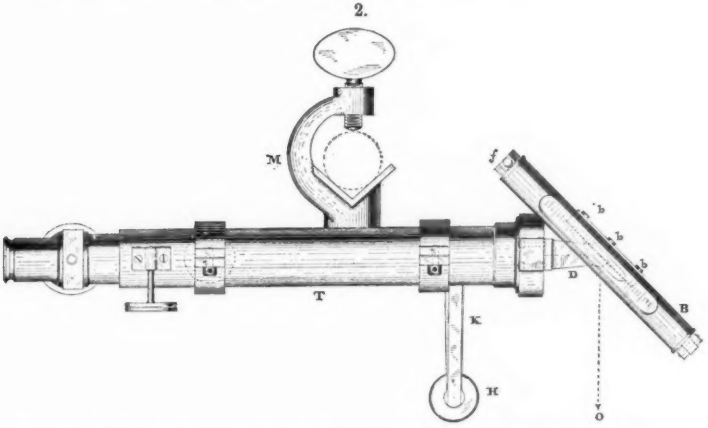


done by rotating the observing telescope itself on a long heavy-vertical axis; in the new form, all of these heavy rotating parts are dispensed with, the observing telescope is fixed in position and the images of the object and scale brought successively into the field by means of a light silvered mirror mounted on a vertical axis just in front of the objective. A

sensitive level attached to the upper end of this axis enables the latter to be set accurately vertical, this adjustment being made as in an ordinary cathetometer.

The complete arrangement is shown in elevation in fig. 1 and in plan in fig. 2. **A**, fig. 1, is the mirror frame and **B** is the level, mounted at the lower and upper end respectively of the short conical axis **C**. The boss **D** in which this axis turns

2.



is attached by means of a geometrical clamp at **E** to a split cap which slips over the end of the observing telescope **T** and is clamped thereon by means of the screw **F**. This much really constitutes all of the essential parts of the new cathetometer, the telescope mounting itself, consisting of the two **L**-shaped bars **K**, **G** and the adjusting screws **H**, **I**, being merely accessory to the convenient adjustment of the axis **C** to verticality. An ordinary open **V**-clamp **M** attached to the lower bar **G** enables the whole arrangement to be clamped to any convenient support; such, for example, as the upright of a heavy retort stand, or an iron wall bracket or even a stiff well-secured water or gas pipe on the wall of the laboratory. If a retort stand or other support with adjusting screws in its base is used, the adjustable support **G**, **K**, etc., on the telescope itself may be dispensed with and the clamp **M** attached directly to the telescope tube as in Plate I, which shows the cathetometer in use.

In the use of the instrument the mirror is first adjusted until it is parallel to the axis of rotation **C** and perpendicular to the optical axis of the telescope **T**. These two adjustments are made simultaneously in the same manner as described in a

previous article in this Journal,* i. e. by bringing the reflected image of the cross wires into coincidence with the wires themselves, revolving the mirror through 180° and correcting one-half of the resulting vertical displacement by means of the adjusting screws *b*, *b*, *b*, against the heads of which the mirror rests, and the other half by means of the screw *e*, which forms part of the geometrical clamp **E**. The level is then adjusted until it is perpendicular to the axis of rotation by means of the screws *f*, *f*, in the usual manner.

Last the telescope is set at the height of the object to be measured and clamped in position and the axis **C** adjusted to verticality by the screws **I** and **H** (or the leveling screws in the base of this support), the level being placed first parallel to the telescope tube and then at right angles to it.† The first of these adjustments is made once for all, the second is tested at the beginning of each day's work, and the third only is necessary at each setting of the telescope.

It is important to notice that a small error in leveling has the same effect in this new form as in the ordinary form, i. e. the error is not doubled by reflection from the mirror, because the telescope and the latter move together, so far as any movement in a vertical plane is concerned. Let us consider the effect of a small error in leveling, first in the vertical plane parallel to the axis of the telescope; second, in the vertical plane at right angles to that axis. Let θ be the angle which the line of sight to the object makes with the first plane considered and α the angle which the axis of rotation *c* makes with the vertical in that plane. Then if ε denote the difference in reading produced by this inclination from the vertical, and r the distance of the object from the axis of rotation, we have evidently

$$\varepsilon = r \sin \alpha \cos \theta$$

and for the difference produced by an inclination α' in a plane at right angles to this

$$\varepsilon' = r \sin \alpha' \sin \theta$$

and for the corresponding errors in comparison of object and scale

$$\Delta = \varepsilon - \varepsilon_1 = r \sin \alpha (\cos \theta - \cos \theta_1) \quad (1)$$
$$\Delta' = \varepsilon' - \varepsilon_1' = r \sin \alpha' (\sin \theta - \sin \theta_1) \quad (2)$$

* A Simple Method of Determining the Eccentricity of a Graduated Circle with only one vernier, F. L. O. Wadsworth, this Journal, May, 1894, vol. xlvii, p. 373.

† The mounting shown in figs. 1 and 2 is especially convenient in performing this last operation, as the screws **H**, **I**, and the third pivot point bear respectively in a slot, plane, and conical hole at the three vertices of a right angled triangle, and the motion of either screw, therefore, affects the position of the axis **C** only in the vertical plane passing through that screw and the pivot point.

In the new form of instrument the best position for the object and the comparison scale is about 90° from the axis of the telescope or in the direction, *o*, fig. 2. If we suppose the object and scale 15° from one another, and symmetrically placed on the two sides of the 90° position, we have for θ and θ_1 respectively $90° \pm 7\frac{1}{2}°$ or $97\frac{1}{2}°$ and $82\frac{1}{2}°$. Hence,

$$\Delta = 0{\cdot}26\, r \sin \alpha \simeq \cdot \tfrac{1}{4}\, r\alpha \qquad (3)$$

and

$$\Delta' = 0 \qquad (4)$$

The general equations (1) and (2) show that care in leveling is only necessary in the vertical plane perpendicular to the line of sight, i. e. in the new form the plane parallel to the axis of the telescope; in the usual form *the plane at right angles to that axis.* Hence if the greatest accuracy is to be attained with the ordinary cathetometer the usual telescope level should be placed at *right angles* to its customary position (or perhaps better still, a second level added in that position), so as to at once call attention to any error of adjustment in that plane. It is strange that this rather important fact should have been overlooked in previous designs.

The actual magnitude of the error in measurement, due to an error in leveling, is, however, always small, unless either the distance of the object from the telescope is considerable, or the difference between the angles θ and θ_1 is larger than 60°. If $\alpha = 5''$ and $\theta - \theta_1 = 15°$ as in (3), the error, Δ, for objects distant $\frac{1}{2}$ M. from the axis of rotation, would be about $\cdot 003^{mm}$ or about the limit of accuracy of setting with the best cathetometers under the best conditions.

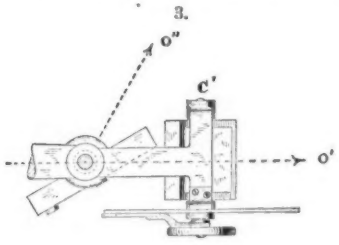
With a good level sensitive to $5''$ per division (the best cathetometer levels are from two to three times as sensitive as this), there is no difficulty in setting by reversal to within less than $\frac{1}{5}$ div. or $1''$, reducing the error under the above conditions to about $\frac{1}{2000}{}^{mm}$.

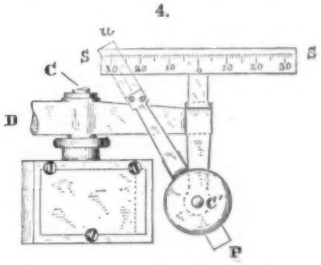
This shows that we may very considerably increase the angular difference $\theta - \theta_1$, without introducing any appreciable error. For when this difference is 60° the value of Δ is only twice the above values or about $\cdot 001^{mm}$ in the last case, a quantity quite negligible in comparison with the errors of setting. This indicates another method of using this new form of instrument to good advantage, i. e., the method of superposition of object and comparison scale. To accomplish this the mirror **A** is half silvered and the scale is viewed directly through the unsilvered half in the direction o' (see fig. 3) the object being at the same time seen by reflection from the silvered half in the direction o''.* In this case we may make the measure-

* The mirror should be half silvered horizontally, i. e. the line of separation of the silvered from the unsilvered portion should be parallel to the axis of rotation, both because the maximum resolution is required in a vertical direction and because, as will be seen later, this management is the better adapted to the use of certain forms of micrometer.

ment either by determining the distance between the image of the point and the image of the nearest mm. division on the scale with an ordinary form of micrometer; or better, by bringing these two images into coincidence by means of a Rochon double image micrometer, an opthalometer or a parallel-plate micrometer. The second method of coincidence has the decided advantages both of greater rapidity, only one setting and reading being necessary instead of two, and of greater accuracy for the same reason, since any error, due to a change in position of any part of the apparatus in the interval between two settings, is thus avoided. This last advantage fully balances the disadvantage of the greater effect of a given error of leveling on account of the greater angular distance between scale and object. One additional cause of error is introduced, i. e., that due to a want of parallelism between the mirror **A** and the axis of rotation **C**; but since this should not exceed a fraction of a second, if the first adjustment has been properly made, its effect is negligible.

Of the various instrumental means for obtaining coincidence perhaps the simplest and most convenient, as well as one of the most accurate, is the parallel plate micrometer first invented by Clausen and quite recently reinvented and much improved by Poynting,* who was the first to adopt it for cathetometric





measurements. Figs. 3 and 4 show in plan and elevation a form of this micrometer modified slightly from that described by Poynting to better adapt it to this particular instrument. It consists simply of a plate of plane-parallel glass, **P**, rotating on an axis **C**′ at right angles to the axis **C** and carried in a fork which is a prolongation of the boss **D** shown in the preceding figures.

The rotation of the plate on its axis shifts the ray from o', which passes through it, and hence also the image of the scale, by an amount Δ which may easily be shown to be

* Phil. Trans., vol. clxxxii, 1891, A, p. 588. See also "On a Parallel Plate Double Image Micrometer," Monthly Not. of the Royal Astron. Soc., vol. lii, No. 8, 1892, p. 556.

$$\Delta = t \sin \varphi . \left[1 - \frac{\cos \varphi}{\sqrt{n^2 - \sin^2 \varphi}} \right].$$

φ being the angle of rotation measured from the position in which the plate is normal to the ray. This expression may be written:

$$\Delta = \cdot \frac{n-1}{n.} t \operatorname{tang} \varphi . \left\{ \left(1 - \frac{\cos \varphi}{\sqrt{n^2 - \sin^2 \varphi}} \right) . \frac{n \cos \varphi}{n-1} \right\}. \quad (1)$$

$$= \frac{n-1}{n.} t \operatorname{tang} \varphi . f(\varphi)$$

The quantity in brackets or $f(\varphi)$ may be shown to be very nearly unity for all values of φ between 0 and 30°. In order to determine its exact value we may develop it into a series as Poynting does, but since this series is only rapidly convergent for low values of φ, it is on the whole better to compute it directly from (1), which is in a form well adapted to logarithmic computation. I have calculated the values of $f(\varphi)$ for values of φ from 5° to 30° and for two values of n, viz: $n = 1{\cdot}5$ and $n = 1{\cdot}55$, about the mean indices of the glass most likely to be used for this purpose. These values are given in the following tables:

TABLE I.

$n = 1{\cdot}5 \quad n-1/n = \frac{1}{3} = 0{\cdot}3333.$

ϕ	$\frac{n-1}{n}$ tang ϕ	$f(\phi)=$	$1+\delta$*	$rs = \text{tang } a \text{ tang } \phi$	$rs-\delta$
5°	·02916	1·00044=	1 + ·00044	+ ·0011	+ ·00066
10°	·05878	1·00162=	+ ·00162	+ ·0021	+ ·00049
15°	·08932	1·00333	+ ·00333	+ ·0033	·00000
20°	·12132	1·00528	+ ·00528	+ ·0045	− ·00078
25°	·15544	1·00681	+ ·00681	+ ·0057	− ·00111
30°	·19245	1·00708	+ ·00708	+ ·00708	+ ·0000

TABLE II.

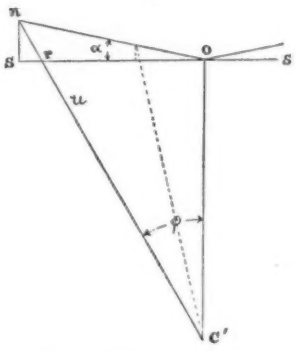
$n = 1{\cdot}55 \quad \frac{n-1}{n} = {\cdot}35484$

ϕ	$\frac{n-1}{n}$ · tang ϕ	$f(\phi)$	$1+\delta$
5°	·03104	1·00024	1 + ·00024
10°	·06257	1·00085	+ ·00085
15°	·09508	1·00162	+ ·00162
20°	·12915	1·00216	+ ·00216
25°	·16547	1·00188	+ ·00188
30°	·20487	1·00002	+ ·00002

* [In a similar table given by Poynting, the sign of δ is erroneously written negative (probably a typographical error), and there is also a small error in the value of δ for $\phi = 10°$, which is however unimportant since δ itself is so very small for this angle.]

An inspection of these two tables shows that in the case of glass of the higher refractive index ($n = 1{\cdot}55$), the maximum value of δ is only 0·2 per cent of $f(\varphi)$, and since the maximum shifting of the image need never exceed 1^{mm} (if comparison is made on a mm. scale), the corresponding correction to the tangent value is only $\frac{1}{500}{}^{mm}$ and may be disregarded. In this case we may read off the value of Δ directly on a straight scale $s\,s$ by means of a pointer, u, which consists of a thin plate of glass or mica on which is ruled a fine radial line. The distance ro from o, to the point of intersection of this line with the longitudinal line $s\,s$ on the scale, equals $c'o$ tang φ and hence is directly proportional to Δ. If we make $c'o$ equal to $17\frac{3}{4}\ t$ in mm., then each mm. on the scale $s\,s$ corresponds to a shifting of the image through $\frac{1}{500}{}^{mm}$. For an angle of 30° $\Delta \simeq \frac{1}{3}\,t$., hence for a shifting of 1^{mm} corresponding to this angle, the plate **P** must be 5^{mm} thick, and the distance $c'o$ therefore about 89^{mm} as laid off in fig. 5. The scale $s\,s$ of fig. 4 is grad-

5.



uated in 2^{mm} intervals so that such intervals correspond to $\frac{1}{25}{}^{mm}$, but it is easy to set and read the position of the pointer to $\frac{1}{10}$ div. or $\frac{1}{250}{}^{mm}$.

In the case of glass of refractive index 1·5 the proportionality between the scale readings obtained in this manner and the value of Δ is not so exact, the error amounting in case of an angle of 30° to nearly $\frac{3}{4}$ of 1 per cent or to nearly $0{\cdot}01^{mm}$. This is a quantity too large to be neglected. Poynting suggests a very ingenious system of link work, whereby the readings on the scale may be made directly proportional to Δ for all values of φ; but this, as he himself recognizes, is hardly practicable on account of mechanical difficulties. We may, however, obtain the desired result very much more simply. An inspection of the values of δ in Table I will show that

they are roughly proportional to tang φ. If we draw a line, *no* (fig. 5), inclined at a small angle α, in each direction from *o*, to the longitudinal line on the scale *s s*, and read in each case to the intersection of this line with the radial line *u* on the pointer; we increase the scale reading by an amount $sr = os$ tang α tang φ, and the new scale reading is therefore

$$os \simeq c'o \text{ tang } \varphi . [1 + \text{tang } \alpha \text{ tang } \varphi]$$

Hence we have only to make tang α tang $\varphi = \delta$, in order to make *os* the new scale reading directly proportional to Δ as before. To find the inclination α of the line *n*, *o*, to the axis of graduation we have only to put

$$\text{tang } \alpha \text{ tang } \varphi = \delta$$

for some particular value of φ. Suppose we do this for $\varphi = 30°$. Then we find

$$\text{tang } \alpha = \frac{\cdot 0071}{\cdot 577} \text{ or } \alpha = 42'$$

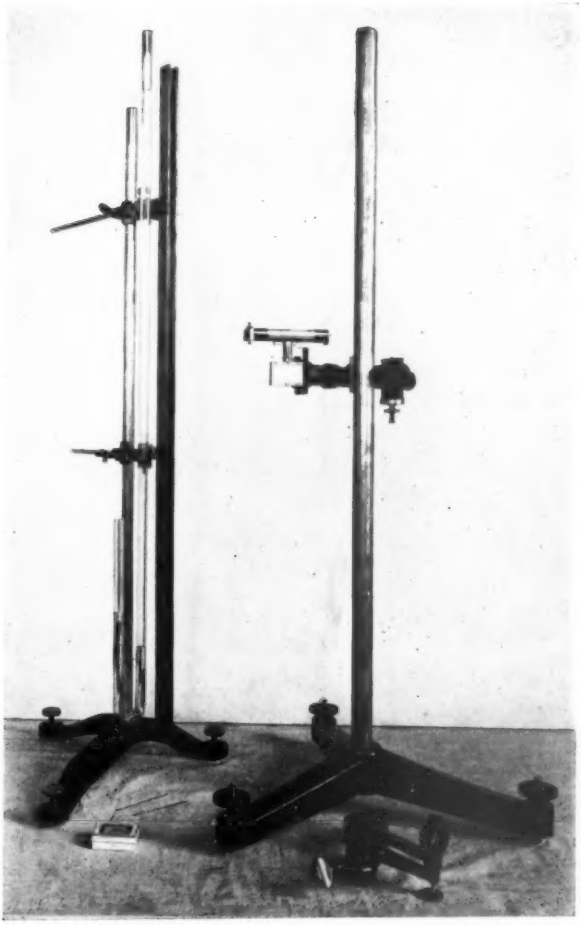
Using this value of α to calculate the values of the scale correction, *rs*, at other points we find the values given in the 5th column of Table I. As will be seen, they differ on the average from the corresponding values of δ by less than $\frac{1}{20}$ per cent; or only about $0{\cdot}0008^{mm}$ at the maximum for $\varphi = 25°$. By this simple method, therefore, the necessity for making any correction to the scale reading, even in the most accurate work, is entirely avoided.

The exact constant of the scale reading for any particular value of the index, differing from those given above, may be either calculated from the above formula or determined experimentally.

In order to always make the value of a 1^{mm} scale division correspond to some convenient fractional part of a mm. the support for the scale is made adjustable in height so that the value of $c'o$ may be always made equal to $\frac{n-1}{n} \frac{t}{a}$ where a is the fractional value desired. One advantage which the rotating plate has over the ordinary eye-piece micrometer, is that its constant remains the same for all distances of the scale from the telescope.*

The above form of parallel plate micrometer may also be advantageously substituted for the eye-piece micrometer in the first instrument described. In this case it should be placed

* The great practical advantage of this form of micrometer over the ordinary form is its much greater simplicity and cheapness. For these reasons it would have been adopted in all of the above instruments had it not happened that we already had on hand a number of micrometer eye-pieces which were available for this purpose.



NEW FORM OF CATHETOMETER.

between the objective and the reflecting mirror **A** or else mounted on the mirror frame itself so as to rotate with it. The last position enables the same instrument to be used either in the method of comparison or in the method of coincidence, but it is objectionable both on account of the increased weight of the moving parts and because of the liability of disturbing the adjustment of the axis or mirror while manipulating the micrometer. It is therefore better to place the rotating plate in the first position indicated and adapt it to either method of use if desired, by making it cover only one-half the field of the telescope, that half of course which is opposite the unsilvered half of the mirror when the coincidence method is used, and opposite the silvered half when the comparison method is employed.

In closing I wish to express my thanks to Messrs. Francis and Kathan, the mechanicians of the laboratory, for the care exercised in the mechanical execution of these designs.

University of Chicago, September, 1895.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *The Determination of Argon.*—By the use of an elaborate apparatus, Schlœsing Jr. has carefully determined the amount of argon in the air. The arrangement was such that the atmospheric "nitrogen" was gradually supplied to the apparatus where it circulated over heated magnesium and copper oxide and through drying apparatus, and the last traces of nitrogen were finally removed by sparking with oxygen. The method was tested by mixing the purest obtainable argon with chemical nitrogen in the same proportion in which they exist in the air and subjecting the mixture to analysis. These tests gave excellent results but showed a slight loss of argon. The author concludes that 100 volumes of atmospheric nitrogen and argon contain 1·183 volumes of argon, while air as a whole contains 0·935 per cent by volume. He believes that these numbers are correct within $\frac{1}{100}$ of their value.—*Compt. Rend.*, cxxi, 525.

In a subsequent article the above-mentioned author describes a continuation of his experiments. Repeated tests of the method invariably showed a loss of argon amounting, on the average, to about 0·7 per cent. This loss is not satisfactorily explained, but the possibility is suggested that argon may have some slight action upon hot metallic magnesium. The author gives the results of a number of analyses, as follows:

	Argon in 100 volumes of atmospheric nitrogen.	Argon in 100 volumes of air containing 79·04 of nitrogen.
Air taken in Paris at about 10 m. above the ground, Sept. 25	1·185	0·9369
" 26	1·183	0·9349
" 30	1·185	0·9367
Oct. 1	1·180	0·9325
" 4	1·185	0·9363
Air taken in Normandy on a hill 305 m. high	1·182	0·9343
Air taken at a height of 300 m. on the Eiffel Tower	1·180	0·9328
Air taken in an iron mine	1·183	0·9534

The above results are not corrected for a supposed constant loss in analysis of about 0·7 per cent. Making this correction, the average results for normal air become 1·192 and 0·941. The variations in the results are within the limits of experimental error, and it must be concluded that argon, like oxygen and nitrogen, in the air is practically constant in amount.—*Compt. Rend.*, cxxi, 604. H. L. W.

2. *A study of Graphite occurring in Pegmatite.* — Having previously shown that all other forms of carbon are converted into graphite at the ordinary pressure by a sufficient rise of temperature, and further that all the graphites produced by crystallization from molten metals possess the property of sprouting when heated after the addition of a little nitric acid, while, on the contrary, graphites produced by simple transformation by heat or by volatilization in the electric arc do not sprout when so treated, MOISSAN has now examined, in this way, a graphite occurring in a pegmatite rock. This graphite was found to sprout, and the author believes that it must have been formed in a manner similar to that produced from molten metals, and that it existed before the pegmatite was formed. Continuing this research, the author has examined a number of other natural graphites from various parts of the world, and finds that a part of them sprout while the others do not. He concludes that the first class seem to have been produced by the action of molten baths, especially of metallic baths, while the second class were evidently formed by the action of an elevated temperature upon any variety of amorphous carbon.—*Compt. Rend.*, cxxi, 538, 542. H. L. W.

3. *The Volumetric Determination of Cyanogen.*—The method of Liebig is carried out by adding a standard solution of silver nitrate to that of the alkaline cyanide in which cyanogen is to be determined, until a permanent precipitate of silver cyanide appears. One atom of silver corresponds to two cyanogens. DENIGÈS has now modified this well-known method so as to greatly improve the delicacy of the end-reaction and to widen

the applicability of the process. He finds that if a small amount of an iodide is present in an ammoniacal solution of a cyanide, silver iodide appears at the end of the reaction, although the method, in its original form, cannot be used in the presence of ammonia. He shows that the amount of silver solution used is rigorously proportional to the cyanogen present, even when considerable amounts of caustic alkalies, varying amounts of ammonia, etc., are present. He recommends the following method for alkaline cyanides: Weigh out one gram, dissolve in water, making a volume of one liter, take 100 c.c. of the filtered liquid, add 10 c.c. of ammonia solution, and about ten drops of a 20 per cent. solution of potassium iodide, and run in decinormal silver nitrate solution until a permanent precipitate appears. When sulphides are present, 10 c.c. of a 10 per cent. solution of zinc sulphate and a few drops of a basic lead acetate solution are added to the liquid before it is made up to a liter. The author proposes the use of a standard solution of potassium cyanide for the determination of silver by titration, the end of the reaction being determined by the disappearance, in an ammoniacal solution, of a slight precipitate of silver iodide. He considers this method preferable to Volhardt's thiocyanate method, but the greater instability of potassium cyanide solutions is evidently not in its favor.—*Ann. Chim. Phys.*, VII, vi, 381. H. L. W.

4. *The Emission of Light during Crystallization.*—Instances of this phenomenon have long been known, and H. Rose, who studied the subject, concluded that it was due to a change from an amorphous to a crystalline condition. He believed, for example, that vitreous arsenious acid when dissolved in hydrochloric acid gave light when it crystallized, while the porcelain-like form of the substance, dissolved in the same way, failed to give the phenomenon. This view, that the amorphous or crystalline nature of a substance could in any way affect the nature of a solution of that substance, is not in harmony with the modern ideas concerning solutions. BANDROWSKI has now shown, as was to be expected, that both kinds of arsenious acid produce the same results under like conditions. He finds the result, in the case of arsenious acid, to depend upon the presence of hydrochloric acid, as no emission of light occurs when the crystallization takes place from water or from alkaline solutions. The author made a series of experiments by dissolving 15 g. of arsenious oxide in 150 c.c. of hydrochloric acid, gradually varying the strength of the acid. He found that with very weak and very strong acid no light was emitted upon cooling to crystallization, and that the maximum effect was produced when the acid contained from 16·5 to 18 per cent. of hydrogen chloride. The phenomenon is described as very brilliant when observed in darkness, sometimes furnishing sufficient light for telling the time by a watch. The light appears in the form of innumerable bright sparks which are accompanied by a peculiar sound, and the whole phenomenon is suggestive of an electric discharge.

Bandrowski has also made a study of the emission of light from mixtures of potassium and sodium sulphates when they crystallize, the circumstance having been originally observed by Rose. Curiously enough, neither of the single sulphates gives the phenomenon, and the author concludes that the formation of a double salt, $2K_2SO_4 . Na_2SO_4$ is the necessary condition. He promises further results in this interesting field.—*Zeitschr. Physikal. Chem.*, xvii, 234. H. L. W.

5. *The Preparation and Properties of Titanium.*—MOISSAN has succeeded in preparing titanium, in a purer state than it has heretofore been known, by reducing the oxide with carbon in his electric furnace. With a current of 100 amperes and 50 volts, a fused or crystallized oxide of an indigo-blue color is obtained. With 300 or 350 amperes and 70 volts a perfectly fused mass of a bronze-yellow color, the nitride, Ti_2N_2, of Friedel and Guerin, is produced. At still higher temperatures the nitride is decomposed, so that with a current of 1,200 amperes and 70 volts, either the carbide, TiC, or titanium itself is obtained, according as to whether carbon is in excess or not, and these products are entirely free from nitrogen. The titanium was obtained in a fused condition, but Moissan states that it is the most refractory body that he has as yet obtained in his electric furnace, being more infusible than vanadium, and still more so than chromium, tungsten, molybdenum and zirconium. The purest titanium obtained in this way contained about 2 per cent. of carbon, bnt was practically free from other impurities. The fused titanium forms a brittle mass, harder than quartz, showing a brilliant, white fracture. Its density is 4·87. When heated, it combines with chlorine and oxygen with incandesence, and with nitrogen with some elevation of temperature. Nitric and hydrochloric acids attack it slowly even when hot, while aqua regia and sulphuric acid dissolve it much more readily. When titianium is heated in the electric furnace with boron and silicon, there are formed borides and silicides, either fused or crystallized, which are as hard as diamond.—*Bull. Soc. Chim.*, III, xiii, 959. H. L. W.

6. *Practical Proofs of Chemical Laws ;* by VAUGHAN CORNISH, 12mo, pp. 92. London and New York, 1895. (Longmans, Green & Co.)—This small text-book gives a series of experiments by which students may verify certain fundamental laws of chemistry, including conservation of mass, definite proportions, equivalent proportions and multiple proportions. The experiments are well devised and, for the most part, satisfactorily described and explained. Results obtained by students, showing a good degree of accuracy, are given throughout the book, and the author states that these pupils were mostly between twelve and eighteen years of age. Such young pupils would probably gain some knowledge of quantitative analytical processes by pursuing such a course, but it seems doubtful if most beginners would fully realize its significance, especially since chemical equations and formulæ are excluded on the ground that they are inadmissible in an exami-

nation of the facts upon which the atomic and molecular theory is based. Teachers of chemistry will undoubtedly find the book useful in furnishing suggestive problems for quantitative work.

H. L. W.

7. *Anleitung zur Molekulargewichtsbestimmung*, von Dr. G. Fuchs, 8vo, pp. 41, Leipzig, 1895. (Engelmann. Price M 1.20.)—This little book deals with the boiling-point and freezing-point methods for determining molecular weights, which have been elaborated by Professor Beckmann. Coming as it does from the pen of one of Beckmann's pupils and from his own laboratory, it may be considered an authoritative work upon the subject. The historical and theoretical bearings of the subject are clearly outlined, but the book is especially intended for use as a laboratory manual for students who are making molecular-weight determinations by the methods under consideration. The operations are well described and illustrated by figures, and the necessary formulæ and tables for making calculations are given and clearly explained. H. L. W.

8. *A Laboratory Manual of Organic Chemistry;* by Lassar Cohn. Translated by Alexander Smith, 12mo, pp. 403. (Macmillan & Co., $2.25.)—This work is a compendium of laboratory methods used in organic chemistry. The first part, dealing with the general methods, contains chapters on baths, crystallization, decolorizing of liquids, distillation, drying solids and liquids, extraction, filtration, determination of melting-points, determination of molecular weights, sealed tubes, and sublimation. The second part, devoted to special methods, embraces chapters on condensation, preparation of diazo bodies, preparation of esters, fusion with caustic alkalies, preparation of halogen compounds, preparation of nitro derivatives, oxidation, reduction, preparation of salts, saponification, preparation of sulphuric acids, and remarks on organic analysis. The methods are illustrated by numerous examples taken from chemical literature, and the great number of references indicates that a vast amount of reading was necessary for the compilation of the book. The work of the translator is very satisfactory. A number of changes in arrangement and additions have been made, with the author's sanction, and another improvement over the German edition is the use of smaller type for matters of subordinate interest. The work has been very favorably received in Germany, where it quickly reached a second edition. It is undoubtedly a very important aid to the investigator in organic chemistry, and the present translation will doubtless find extensive use among English-speaking students.

H. L. W.

9. *Organic Chemistry, The Fatty Compounds*, by R. Lloyd Whiteley, 12mo, pp. 290. London, 1895. (Longmans, Green & Co.)—The author aims to give students an intelligible and connected account of the theory of the subject, and also to provide them with such information as shall enable them to gain a prac-

tical acquaintance with it. The second purpose has evidently been more successfully carried out than the first. To a beginner in the laboratory the book would be of much practical aid, as the details for the preparation of compounds are clearly and copiously given, but as a guide to the systematic study of the paraffine compounds and their chemical structure and behavior the usefulness of this volume seems doubtful. W. T. H. H.

10. *Histoire de la Philosophie Atomistique, par* LÉOPOLD MABILLEAU, 8vo, pp. 560. Paris, 1895. (Imprimerie Nationale.)—As the title indicates, this work is a history of the various forms of atomic philosophy, and it includes discussions of Hindu and Grecian systems, as well as the theories of the Arabs and alchemists and finally modern atomistic philosophy and the atomic theories of science. The work has been crowned by the French Academy of moral and political science and is evidently a notable philosophical production. The part devoted to scientific theories occupies but a small portion of the book, and while this subject is well presented from a historical standpoint, it offers little that is novel to well-informed chemists and physicists. H. L. W.

11. *Modern Copper Smelting*, by EDWARD DYER PETERS, JR. Seventh edition, 8vo, pp. 642. New York, 1895. (The Scientific Publishing Co.)—The popularity of Dr. Peters' work on the metallurgy of copper is shown by the fact that it has gone through seven editions since 1887. The work has been the recognized authority upon the subject, both from the theoretical and practical points of view, since its first appearance. The new edition has been re-written and greatly enlarged, bringing the subject up to date and describing the prevailing practice in all parts of the world. The number of working-drawings has been largely increased, and much new matter of a very important nature has been added. In this connection the chapters upon the Bessmerizing of copper mattes, the electrolytic refining of copper and on pyritic smelting deserve special mention and commendation. The author uses the term "pyritic smelting," not in the sense of smelting with sulphides in the old-fashioned way to produce matte, but, as he defines it, "the fusion of sulphide ores by the heat generated by their own oxidation, and without the aid of extraneous heat such as carbonaceous fuel, etc.," a blast-furnace operation which has lately become an accomplished fact in several different localities. H. L. W.

12. *Comparison of the light-emission power of bodies at high temperatures.*—An important research by Mr. CHAS. E. ST. JOHN, late holder of the John Tyndall scholarship of Harvard University, has just been published. This research was conducted under Professor Warburg in Berlin, and led to an interesting method of comparing the light-emissive power of different bodies. The question has an immediate practical bearing in relation to the Auer burner and the Welsbach burner, the light of which is produced by the vivid incandescence of the various oxides of the rare earths zirkonium, yttrium, lanthanum, etc.—in the Bunsen

burner. Mr. St. John shows that the method of coating an incandescent platinum wire with the various oxides, the light-emissions of which are to be examined, leads to inaccurate results at high temperatures. He was led to examine also the mooted question whether the light of the above burners is rich in phosphorescent and fluorescent rays. Various methods which he employed, however, showed that these rays were very slight. The most important part of the research relates to the use of what may be termed the oven method of testing the light-emission. In this method the two bodies whose emissive power is to be determined are placed in an oven the temperature of which was raised 1100°–1200° C., a range of temperature which was determined by the pyrometer of Holborn and Wien. Two pieces of platinum foil were suspended side by side in this oven and the observation of their incandescence was made through a suitably placed window, by means of a Glan's spectrophotometer. A Triplex lamp served as the standard light. When one piece of foil was coated with the oxides it appeared brighter than the uncoated piece. If one piece of foil was inclined to the wall of the oven so that the reflected rays were sent through the window the two pieces of foil could be made to appear of the same intensity. The sum of the direct and reflected light is then for both pieces of foil equal. The uncoated piece must reflect just as much more light than the coated as it is deficient in the amount of direct light it can transmit. This is in accordance with Kirchhoff's law that in a heated space a bundle of rays made up of direct and reflected rays from a surface shows the same peculiarities that a bundle of rays from a dark hot body would show. Mr. St. John utilized this idea by bringing a porcelain cylinder into the neighborhood of the pieces of foil. The bare platinum could then be quickly distinguished from the surrounding hot walls and appeared darker than the coated platinum. As soon as the rod took the temperature of the oven the field of view appeared uniformly bright.

The spectrophotometer was adjusted for light of a determined wave length, and the image of one of the two bodies was thrown on the slit. The porcelain rod was then placed in the furnace, the light was observed; by means of a piece of plane parallel glass, the image of the other body was brought into the field. The porcelain rod acts to cut off the reflected light. Mr. St. John gives the following table:

$\lambda = 0{\cdot}515$

	Platinum.	Magnesium oxide.	Zirkonium oxide.	Erbium oxide.	Lanthanum oxide.
According to the electrical method of glowing platinum	1·00	1·26	1·81	1·70	1·88
According to the oven method	1·00	3·81	4·04	3·35	2·27

The inaccuracy of the electrical method is clearly shown. The results of Mr. St. John show that the Kirchhoff's law leads to a practical method of measuring in an oven the light-emission of bodies at high temperatures.—*Ann. der Physik und Chemie*, No. 11, 1895, pp. 433–450. J. T.

13. *Method of proof of the law of radiation of an absolutely dark body.*—W. WIEN and O. LUMMER, who had apparently been working independently upon the problem upon which St. John was also working (Ann. der Physik und Chemie, No. 11, 1895, p. 433), state the conditions which should be fulfilled in making observations according to Kirchhoff's law, and for the measure of radiation according to Stefan's law. They suggest that two pieces of thin platinum foil brought to incandescence by an electric current be placed near each other. One is provided with a slit through which the other is viewed. The inner appears much brighter than the outer. The temperature can be determined by the increase of resistance of the platinum. The arrangement can be used also as a bolometer, the radiation to be measured being sent through the slit and both pieces of platinum foil thus heated. In this way a result is obtained which is independent of the individual peculiarities of the absorbing and emitting surfaces, and the absolute radiation can be measured more correctly than by previous methods.—*Ann. der Physik und Chemie*, No. 11, 1895, pp. 451–456. J. T.

14. *Plasticity of Ice*, by O. MÜGGE.—In corroboration of the results of McConnell (Proc. Roy. Soc., xlviii, p. 259, 1890; and xlix, p. 323, 1891), experiments are made upon the bending of small bars of ice, held horizontally, supported at the ends, and loaded at the middle. If such a bar, or crystal, is so cut that the optical axis is perpendicular to the length, the load causes considerable bending; but a rod having the optical axis horizontal shows no appreciable bending under these conditions. This agrees with the supposition that the crystals consist of thin laminæ, formed of a flexible but almost inextensible substance, the interspaces being filled with a separating medium which is sufficiently viscous to retard the mutual gliding of the plates. Ice, in this respect, resembles $KMnCl_3 . 2aq.$, where the deformation results, similarly, from a motion of translation of the component laminæ, retarded by viscous matter in the interspaces, The experiments seem to show that this motion of translation takes place with equal facility in all directions parallel to the end surfaces; and, within the limits of $-3°$ C. and $-16°$ C., the extent of the motion, for a given load, appears to be independent of temperature. (Nach. G. Wiss. Göttingen, pp. 173–174, 1895.)—*Phys. Soc. Abstracts*, Nov., 1895.

15. *Ueber den Magnetismus der Planeten von* ERNST LEYST. 118 pp. 4to. St. Petersburg, 1894. (Repertorium der Meteorologie herausgegeben von der K. Akad. der Wissenschaften.)—The author has exhaustively examined the photographic records of the magnetographs at St. Petersburg, and later at Pawlowsk between 1873 and 1889, to see if it is possible to trace any systematic effect produced on the terrestrial magnetic elements by the other planets of the solar system. In this paper the author deals at great length with the declination records, and somewhat less fully with those of horizontal force. Three methods are em-

ployed:—(1st) The mean declination for the day at which the inferior or superior conjunction in the case of the inferior planets, or conjunction or opposite in the case of superior planets, takes place is compared with the mean declination for neighboring days or for the month. (2d) By means of the mean value of the secular change for the period 1873–1885 the value of the declination for the time of conjunction, etc., is compared with the actual value. (3d) The value of the diurnal range at conjunction, etc., is compared with the mean value. Although the differences obtained are excessively small, amounting as they do to only a fraction of a minute of arc, and large as is the probable error, the author considers that the numbers obtained point to the planets being so highly magnetized that they are capable of affecting the magnetism of the earth to an extent which is recognizable with the magnetographs now in use.—*Phys. Soc. Abstracts*, Nov., 1895.

16. *Molecules and the Molecular Theory of Matter*, by A. D. Risteen. 223 pp. Boston and London, 1895. (Ginn & Company.)—This popular and yet scientific presentation of the accepted molecular theory of matter with reference to solids, liquids and gases, will aid many to gain a clear idea of a difficult subject and one which has not been written out before in connected form. The language is for the most part simple and the illustrations numerous and helpful. The volume is based upon a lecture delivered a year since and the same form of address has been maintained in the expanded work; it may be questioned whether this is an advantage.

17. *School Physics: a new text-book for high schools and academies*, by Eleoy M. Avery. 608 pp. New York and Chicago. (Sheldon & Company.)—This new edition of Avery's Physics is commendably fresh in matter, introducing many new topics and new applications of physical principles. At the same time, it retains the good features of earlier editions, conspicuously clearness of style and arrangement, and liberality of illustrations and of exercises and problems. In the hands of a good teacher, properly equipped as to laboratory apparatus, it should produce excellent results.

II. Geology and Mineralogy.

1. *Reconnaissance of the Gold Fields of the Southern Appalachians;* by George F. Becker, Ann. Rep. U. S. Geol. Surv. 1894–5, Part III. (Abstract prepared by the author.)—This report is based on field work done in 1894. Besides due reference to the results obtained by earlier observers in the same field, it also contains a digest of the literature dealing with the gold deposits of the maritime provinces and the Green mountains, the purpose being to present in one paper the most noteworthy facts concerning the occurrence of gold on the entire eastern side of the continent. In the northern portion of this region gold has been found in important quantities in Nova Scotia, and a considerable

amount of the metal has been obtained in the Chaudière district at the northern end of the Green mountains. In the South a belt of gold-bearing country passes through Virginia from the neighborhood of Washington, a second more important belt stretches through North Carolina past Charlotte into South Carolina; an auriferous area occurs in the heart of North Carolina at the South mountains, and still another belt crosses northern Georgia extending into Alabama. Field studies were made only of the deposits in Georgia and the Carolinas.

The first discovery of gold in the South seems to have been due to Ponce de Leon in 1513 and some curious notes on the early reports are set down. The first discovery which drew the attention of the present population to the gold resources was at the Reed mine, North Carolina, in 1799 and no "gold fever" occurred until 1830. The total production of the South up to the end of last year is estimated by the Mint authorities at above 45 million dollars. This does not represent a very large annual yield, but then it also represents only a small annual effort. In the palmy days of the Comstock about 10 miles of galleries were driven each year. It is doubtful whether all the galleries run during the century in the southern gold mines would aggregate 10 miles.

The rocks of the Georgian belt are mainly gneisses and gneissoid schists, believed by the geologists of the survey to be Archaean from evidence occurring farther westward. They are intersected by granite dikes supposed to be Algonkian. In the South mountain area the rocks are similar to those in Georgia. In the Carolinian belt granite is not absent, but the main mass of the country is composed of metamorphosed sedimentaries and volcanics. These last belong to the series studied by the late George H. Williams and with the sedimentaries are supposed to be Algonkian. To the northward the continuation of the volcanics is known to be pre-Cambrian.

All the rocks associated with gold in place have been subjected to profound dynamical action excepting a portion of the dikes. Almost all the country has acquired slaty cleavage, which strikes in a direction about parallel with the general trend of the Appalachians. In some areas the dip is westerly and in some easterly. It is suggested that these two groups of cleavages do not indicate forces of different directions but may be the conjugate cleavages due to a force of nearly constant direction as indicated in the author's theory of slate.*

Subsequent to the genesis of the cleavage a wide spread dislocation took place under the action of forces not coinciding in direction with that to which the cleavage is due. This fresh disturbance opened the fissures now occupied by quartz, and the direction of faulting, in all instances observed, was normal. In a large proportion of cases the effect was to split the rocks approximately along their cleavage. In the South mountain area, however, the strike of the schists is abnormal and the astonishingly regular vein-fissures cut sharply across the cleavage.

* Bull. Geol. Soc. Amer., iv, 1893, pp. 13–90.

Since the deposition of ore there has been no disturbance at all comparable to those which preceded this deposition. The associated dikes too are little disturbed. The greater part of the gold is certainly Paleozoic or older, for the Newark sandstones contain transported gold. There is no known disturbance in the Paleozoic which would answer in intensity or vulcanicity to those mentioned. These facts and such evidence as is available concerning the age of the ancient eruptives point to the Algonkian as the age of gold deposition. The slaty cleavages are older than the quartz veins and they are mechanically equivalent to distributed orogenic dislocations. Thus they indicate that as far back as the Algonkian a range or ranges existed which belonged to the Appalachian system. It will not be surprising if the tendency to mountain-building along this trend, which has manifested itself in the Pleistocene, should be detected even in the Archaean.

The report contains a long list of "gangue minerals" with localities and literary references. No less than sixty of these minerals are recorded, including, however, the sulphides as well as the earthy salts. The propriety of using the term gangue to include those metallic minerals which are not ores of the metal sought is open to question, but the term is very convenient and, when discrimination is requisite, it is easy to specify earthy gangue or metallic gangue. The conclusion reached from study of the ores is that "the gold ores of the South are quartzose deposits with very subordinate admixtures of carbonates in which pyrite is always present, while chalcopyrite is common, and galena, mispickel, and zincblende are by no means rare. The long list of other minerals found in the veins is unimportant, excepting in so far as it assists in elucidating the genesis of the ores." The gold ores of the South are thus substantially like those of most auriferous regions.

The quartz veins of the southern Appalachians have been regarded by several previous observers as beds contemporaneous with the rocks, but W. B. Rogers early pointed out that the conformity between the veins and the rock laminæ is only approximate. This important observation is fully borne out, and it appears that the structure with which the quartz is often approximately conformable is not bedding at all, but slaty cleavage. Almost everywhere the veins occasionally break across from one parting to some parallel one, and in most cases angular fragments of slaty wall rock occur imbedded in the quartz. Many of the deposits are not solid veins but zones of small lenticular veinlets separated by thin sheets of slate. For these the term *stringer-lead* is proposed, since they do not answer to the definition of a vein, which is "the filling of a fissure." No evidence of replacement was detected in these deposits, which seem to occupy only openings due to fracture. In many cases, however, the slate is impregnated with auriferous sulphurets for some inches from the quartz.

In the Carolina belt, particularly among the ancient volcanics of that region, impregnations occur which correspond closely to the Norwegian Fahlbands. The most profitable mine of the South, (the Haile in South Carolina) is on such an impregnation.

The placers of the South are of two well marked types accompanied by intermediate gradations. Ordinary auriferous stream gravels occur, but somewhat more frequent are masses of rock in place which are intersected by innumerable gold-bearing quartz seams, sometimes no thicker than paper, and which have subsequently been decomposed to a great depth. The term *saprolite* is proposed and employed as a general name for thoroughly decomposed, earthy, but untransported rock. Such a word is much needed and the only term ever proposed quite corresponding to it is "geest," which for good reasons has failed to find acceptance. Between the saprolitic placers and the stream gravels there are naturally transitions. Other things being equal, the water-worn gold is of greater value per pennyweight than the gold of the saprolite. The refining effect of running water was known to Oviedo and even to Pliny. One nugget of 8 pounds 5 ounces and another of 10 pounds have been discovered during the present year at the Crawford mine, North Carolina.

The report contains, in addition to the systematic portion, descriptive notes of the principal districts, and a bibliography of the subject, and it concludes with a review of the northern deposits, particularly those of Nova Scotia. It appears that these two are probably Algonkian and in most of the details of occurrence they resemble those of the South.

It is probable, therefore, that near the end of the Algonkian a set of chemical and physical conditions prevailed from Newfoundland to Alabama favorable to the deposition of auriferous quartz, and similar to the conditions which existed in the Sierra Nevada of California about the beginning of the Cretaceous.

2. *Geological Survey of New Jersey.*—The Annual Report for 1894 was received in November, 1895, and contains three parts, in all 303 pages, plates i–xi, one figure and a large colored geological map. Part I is the Report of Progress on the Surface Geology by ROLLIN D. SALISBURY, and nearly completes, with what has already appeared, the work on the northern half of the state. The author calls attention to the emphasized importance of the influence of stagnant ice upon the stratified drift of the valleys of the northern part of the state. Additional particulars are given regarding the Pensauken and Jamesburg formations. Accompanying the report are four map-sheets bound in with the text and a large colored geological map of the surface formation of the Valley of the Passaic, covering the area of topographic sheet 6. Part II is the Report on Artesian Wells in Southern New Jersey, by LEWIS WOOLMAN, in which the depths of the various formations are noted, the underground stratigraphy worked out, and numerous lists given of the fossils met with in the strata penetrated. Part III is C. C. VERMEULI's Report on Forestry in the northern part of the state, accompanied with a map showing the distribution of forests in the state. H. S. W.

3. *Geological Survey of the State of New York.*—The 13th annual report of the State Geologist for the year 1893 appears in two large volumes full of interesting material. Volume I, Geology, (pp. 1–597) contains four valuable papers on the Livonia salt shaft, based upon the investigations of JAMES HALL, D. D. LUTHER and J. M. CLARKE. A shaft, 12x22 feet, was sunk in Livonia, Livingston County, New York, penetrating from the Hamilton rocks outcropping at the surface, 1432 feet to the base of the salt group of the Silurian. Fossils and accurate measurements were preserved, so that the section serves to give an accurate record of the thickness of each member of the series, and of the exact position, succession and recurrence of the faunas for this portion of the geological scale. The record of the shaft and sequence of rocks was made by Mr. Luther, and the study and report upon the fossils by Mr. Clarke, and the whole furnishes an exceedingly valuable record for the study of the succession and modification of fossil faunas with passage of geological time.

The second part of this volume contains a number of reports prepared during the construction of the geological map under the supervision of the United States geological survey. These reports are as follows: On the Helderberg limestones, on the geology of Albany and Ulster Counties and on the geology of the Mohawk Valley, by N. H. DARTON; on the economic geology of Albany County, and on the geology of Ulster County, by F. L. NASON; on the geology of Essex County, by J. F. KEMP; of Clinton County, by H. P. CUSHING; on the general and economic geology of parts of St. Lawrence and Jefferson Counties, by C. F. SMYTH, Jr.; on the geology of Cattaraugus and Chautauqua Counties, by F. A. RANDALL; and of Chenango County, by J. M. CLARKE. Mr. Clarke also contributes a list of publications relating to the geology and paleontology of the State of New York from 1876–1893.

Volume ii, Paleontology, in addition to an extract from vol. viii, Part 2 of the Paleontology of New York on the Evolution of the genera of the Paleozoic Brachiopoda, contains a paper on Platycnemic Man in New York, by W. H. SHERZER; also a discussion of the different genera of Fenestellidæ, by GEO. B. SIMPSON; and, finally, Part II, An Introduction to the study of the Brachiopoda, intended as a hand-book for the use of students, by JAMES HALL, assisted by JOHN M. CLARKE. This last work completes a most valuable contribution to Paleontology, and furnishes the American student of stratigraphical geology with the means of precise and thorough work which were almost impossible without such a work on these indispensable indicators of the geological horizons of Paleozoic rocks. H. S. W.

4. *Mollusca and Crustacea of the Miocene Formation of New Jersey;* by R. P. WHITFIELD, Monograph XXVI, U. S. Geol. Survey, 1894, 4°, 193 pp., 24 pl.—This monograph, originally prepared for the New Jersey Survey, was finished by the author and transmitted for publication by the late Professor Cook in

1889, but was not published until 1894. The author has gathered from various sources information regarding all the then known species of the miocene formation of New Jersey. One hundred and four species are recognized; of these thirty-five species are reported from New Jersey only, and no very close representatives of living species are in the list. "No living forms," the author observes, "have been found in the New Jersey deposits that are not also known to occur in some of the more southern localities." A single species of *Discina* is the only representative of the Brachiopods, a fact in keeping with the almost complete absence of Brachiopods from the American Atlantic Tertiary. We observe, upon looking over the descriptions, that several species when compared with their more southern representatives, are of noticeably smaller size; as in the cases of *Ostrea percrassa, Arca centenaria, Astarte distans, Cardita granulata, Carditamera arata, Cardium craticuloides, Venus stamínea, Fasciolaria sulcosa, Tritia bidentata.* This probably indicates that the locality was on the northern border of the geographical distribution of the fauna. It would be interesting, geologically, to know what relation the species which still live bear to living representatives in this respect. H. S. W.

5. *The Climates of the Geological past* and their relation to the evolution of the Sun; by Eug. Dubois, pp. 1–167, (Swan, Sonnenschein & Co.) London, 1895.—The author, whose remarkable report on *Pithecanthropus* has been already noticed in these pages, sets forth in this essay the hypothesis that the climatic changes, indicated by the geographical distribution of fossils upon the earth's surface, are due to changes in the heat radiated from the sun. Following Janssen, he assumes that differences of the stars, in color and spectra, indicate differences in their temperature, Thus, the stars which are rich in violet rays, like Sirius, are assumed to be at an extremely high temperature; yellow stars, like Capella, less hot; while those of red color, like Betelgeuze, are in the third stage of cooling. The numbers of the stars of each color is estimated, and the relation of the numbers is taken as an index of the relative duration of each stage; on this hypothesis the white stage is estimated to have continued 58.5%, the yellow stage 33.5% and the red stage 8% of the total luminous existence of each star. The sun, as one of the stars, is assumed to be in its yellow stage of evolution. The author's hypothesis is expressed in the following passage, viz: "Now, since from the sun's history we learn that, during the greater part of its existance as a white star, it was much hotter, and on passing relatively rapidly from the white to the yellow stage, it lost much of its heat, we see, on the other hand, that the heat received by the earth underwent the same changes, for after a very long period of warmth, a relatively rapid cooling set in, finally reaching the present condition—then we may assume that the period of the cooling down of the climates coincided with the transition from the white to the yellow stage, the period of rapid cooling of the

sun. The present thermal condition at the earth's surface was developed during the Tertiary period and was fully attained at the beginning of the Pleistocene period—a date, geologically speaking, so recent that the time which has since elapsed may perhaps be estimated as but one-fiftieth of the time which elapsed since the beginning of the Palæozoic age. We, therefore, may further conclude that our sun only comparatively recently entered its yellow stage, and we may, without committing a great error, consider that it has now passed $\frac{3}{5}$ of its life as a luminous and heating star and that it has still $\frac{2}{5}$ before it." In the course of the discussion the chief facts in evidence regarding variation in climate during geological time are brought together in concise and logical form, and are clearly stated. We think the author is incorrect in assuming that "the supposition of a formerly greater amount of carbonic acid in the atmosphere can now no longer be seriously discussed." H. S. W.

6. *Geological Biology*, an introduction to the geological history of organisms, by HENRY S. WILLIAMS, pp. 395, figs. 1–150. New York, 1895. (Holt & Co.)—The problems of biology, regarded as specially geological in this treatise, are those concerning the history of organisms, their relations to time and varying conditions of environment, and the laws of the modification of characters and the acquirement of differences. As is stated in the preface, "it is evident upon reflection that the biologist proper, who deals alone with the organisms now living upon the earth, must rest with a theoretical interpretation of the laws of evolution. To the geologist the records of evolution are open for direct examination, and geological biology is a scientific treatment of the observed facts of evolution." With this idea in mind the author has put together in systematic form discussions of some of the chief problems desirable as preparation for serious work in paleontological investigation. The general subjects elaborated are the geological time-scale, its divisions, its nomenclature and the principles of its formation, and estimates of the length of geological time; fossils and their interpretation; geographical distribution; the species; the organism; principles of classification, etc.

In the treatment of special topics, such as the modification, acquirement, plasticity and permanency of characters, typical series and groups of organisms are selected for detailed examination, in order to illustrate the exact meaning of the principles involved. The book, as a whole, is a much needed introduction to the study of the history of organisms for the specialist, and is an enunciation of general principles for those looking for a comprehensive statement of the chief facts in the case. It covers a field heretofore covered by historical geology, which in the rapid differentiation of sciences bids fair to take a place of its own as organic, in contrast to inorganic, geology.

7. *Mikroskopische Physiographie der massigen Gesteine von* H. ROSENBUSCH. 3d ed. enlarged and revised, 8vo, first half, pp. 552. Stuttgart, 1895.—The great impulse which the science of

petrology has received in the last ten years is nowhere more clearly to be perceived than in the increased size of this new edition of Prof. Rosenbusch's well known work over that published in 1887. And this increase marks well the incessant activity of the author in the coördination of the vast mass of material which has been published since that date.

It is needless to say that the appearance of this work will be greeted with the keenest interest by all petrographers. No one has held a more commanding position in this branch of science than the author, and no one has exerted a greater influence in its development through his pupils, especially in this country, from which they have been largely drawn.

It would, therefore, be a matter of interest to present a full review of its contents, but in the brief limits of this notice of its appearance it is only possible to say that the work is kept strictly within the limits set in the former editions, that is, to the microscopical physiography of the igneous rocks; general petrology and chemical and geological relations being confined by brief mention within the smallest possible limits, while the author's views are often hinted at rather than actually expressed.

The ideas which the author has advanced during recent years upon the classification and relationships of igneous rocks in various brief publications are here affirmed and their influence is everywhere observable upon the subject-matter of the work. The course laid down in the past is here steadily pursued to a logical conclusion.

In his preface the author states that he still retains the division of the extrusive rocks into two groups dependent on geological age, though it is clear from his remarks that he would prefer to do away with it.

The present half of the work comprises the plutonic rocks ("*tiefengesteine*") and the "dike rocks" ("*ganggesteine*"). Among the latter, as must be expected, we find a considerable number of new types and names expressed.

We note with regret that the author has felt obliged to confine the work so strictly within the limits mentioned above. Analyses of the types described would have added greatly to the convenience and value of the work. We trust that the author may see his way in the future to supplement this work by one dealing with the many phases of petrology, either wanting or all too briefly expressed in this volume. Its appearance would certainly be received with the greatest interest by all workers in this branch of science. L. V. P.

8. *The Rubies of Burma and Associated Minerals—their Mode of Occurrence, Origin and Metamorphoses.* A Contribution to the History of Corundum. By C. Barrington Brown and J. W. Judd.—An abstract of the paper bearing this title is given in a recent number (No. 345) of the Proceedings of the Royal Society. It details the investigations carried on in the field under the auspices of the government by Mr. Barrington Brown and also the results of a petrological and mineralogical examina-

tion by Prof. J. W. Judd of the specimens collected. The following pages are quoted from the source named:

"The famous ruby district of Upper Burma was almost unknown to Europeans before the annexation of the country by the British. It is situated about 90 miles N.N.E. of Mandalay, and about 11 miles E. of the military post of Thebayetkin, on the Irrawaddy. The tract, so far as explored, is about 26 miles long and 12 broad, and lies at elevations varying from 4,000 to 5,500 feet above the sea-level. The principal mining center in this district is Mogok, and the present workings for rubies extend over an area of 45 square miles; old workings, however, being found over an area of 66 square miles. The principal mining operations are carried on in the three valleys of Mogok, Kathay, and Kyatpyen; but there are some smaller outlying districts, in which mines were formerly worked, in the Injouk Valley, near Bernardmyo, at Wapudoung, 11 miles E. of Thebayetkin, and at Launzee, 8 miles S.W. of Kyatpyen. There is also a small tract of ruby-bearing rocks (crystalline limestone) at Sagyin, 24 miles N. of Mandalay; and it is asserted by the natives that two other limestone hills, 15 miles N. of Sagyin, have yielded rubies; while old ruby workings were found in making the railway at Kauksay, 30 miles S. of Mandalay. It is also probable that ruby-bearing limestones, and the alluvial earths derived from them, may be found in portions of the adjoining Shan States. Indeed, at a point about 25 miles southward from Mogok, in the Shan State of Mainglôn, Dr. F. Noetling, of the Geological Survey of India, has found that rubies have been obtained from the alluvium of a stream that flows from the mountains that lie considerably to the S.E. of the Mogok District.

The rubellite (red tourmaline) of the same district was found by Mr. Barrington Brown not to occur in association with the rubies, but to come from certain gneisses and schistose rocks. The locality which yields this gem, so highly prized by the Chinese, is Nyoungouk, 10 miles S.E. of Mogok; the alluvium which yields the rubellite appears never to contain rubies and spinels. Black tourmaline (schorl) has been extensively worked, as shown by Dr. F. Noetling, in the Shan State of Mainglôn, not far from the rubellite locality.

In the mountainous tract which includes the ruby districts, the general trend of the hill ranges is from east to west. The bottom of the Mogok Valley, in which the principal workings are situated, lies at a height of 4,100 ft. above the sea; while the loftiest mountains of the range to the north and east are the Chenedoung Peak, 7,362 ft., and the Taungnee Peak, 7,775 ft. above the sea-level. The alluvia of the valleys of Mogok, Kathay and Kyatpyen are formed by streams flowing southwards from this mountain chain; while those of the valleys of Injouk and Kabein are deposited by streams flowing in the opposite direction. The district, which is a somewhat malarious one, has an annual rainfall of about 80 inches; but in March, April, and May, the supply of water for mining operations is deficient.

The mountains are composed of various gneissic and granulitic rocks, occasionally passing into schists. Subordinate to the general mass of gneisses, often containing garnets, are certain peculiar varieties of foliated and massive rocks, including both acid and basic types, with limestone bands, often of a highly crystalline character. It was in these limestones that the rubies and spinels were found to be embedded, associated with graphite, phlogopite, pyrrhotite, and many other minerals. The sides of the hills are found to be shrouded in a deposit of hill-wash, often 50 ft. in thickness, composed of fragments, derived from the mountains, embedded in a clayey matrix. On the bottoms of the larger valleys there are extensive level deposits of alluvial matter, consisting of brown, sandy clay, resting on coarse gravels, which in turn cover other argillaceous beds. It is in these lower clay beds of the river alluvia, and in similar deposits formed in gullies in the hill-wash, that the rubies, spinels, and other gems of the district are found.

Mining operations for the obtaining of rubies are carried on in Burma in four different ways. (1.) In the alluvia, "twinlones," square pits from 2 to 9 ft. across, ingeniously timbered with bamboo, are sunk to the ruby earth, the drainage of the pits and the removal of material being effected by baskets attached to balance poles, both made of bamboo. (2.) In the hill-wash long open trenches, called "hmyaudwins," are carried from the sides of a gully, and the earth is washed out by streams conveyed into the trenches by bamboo pipes. (3.) In the caves and fissures filled with earth which abound in the limestone rocks, regular mines—"loodwins"—are opened, and the productive ruby earth is followed for long distances by means of shafts and galleries. (4.) The limestones which contain the rubies are at one or two points quarried, and the gems are obtained by breaking up the rock masses.

The extensive rubellite mines at Nyoungouk are worked in a somewhat similar plan to the "hmyaudwins." Water is delivered by a number of bamboo pipes at the head of the almost vertically exposed faces of alluvium; and as the masses of the latter are loosened, the miners dash water upon them from shovel-shaped baskets, and are able to detect and pick out by hand the brilliantly colored stones exposed on the washed surfaces.

The petrology of this district of Upper Burma, in which the rubies, spinels, and rubellite occur, presents features of the greatest geological interest. In many respects the petrology of Burma exhibits close analogies with that of the corundiferous localities of Ceylon, the Salem district, and other portions of the Indian peninsula; but some of the phenomena presented by the rocks of the Burma ruby district do not appear to find a parallel in any of the gem-yielding tracts described by de Bournon and more recently by Lacroix.

The general mass of gneissic rocks composing the mountainous district in which the ruby localities are situated are of interme-

diate chemical composition, and consist of biotite-gneisses, biotite-granulites, and, more rarely, biotite schists—rocks in which hornblende is rare or altogether absent, but which, on the other hand, are often remarkably rich in garnets. Neither corundum nor spinel have been certainly detected in these rocks.

Interfoliated with these ordinary gneissic rocks, which form the great mass of the mountains, we find rocks of much more acid composition, including very coarse pegmatites and graphic granites, aplites and granulites (leptynite or Weiss-stein), granular quartzites, and orthoclase-epidote rocks. The orthoclase of these rocks frequently contains inclusions of fibrolite and other minerals, it often exhibits the "murchisonite" modification and partings, and is not unfrequently converted into "moonstone;" still more complete alterations of the orthoclase into epidote, muscovite, and kaolin being by no means uncommon. In the rubellite district of Nyoungouk these acid rocks contain pink and blue tourmaline (rubellite and indicolite), often beautifully zoned, and it is probably from rocks of this class that the fine gem rubellites are derived.

Of still greater interest are certain other subordinate rocks of basic and sometimes ultra-basic composition. These include the remarkable pyroxene-gneisses and pyroxene-granulites, which have in recent years been described as occurring in so many widely-scattered regions—such as Ceylon, Southern India, Central and Southern Europe, Norway and Sweden, Brittany, Spain, Algeria, Eastern, Western, and Southern Africa, the United States and Canada, Brazil, and New Caledonia. In these rocks the feldspars are for the most part basic ones, near to anorthite; the crystals almost always exhibit the phenomenon described by French petrographers as "quartz of corrosion," and the partial or complete transformation of these feldspars into scapolite ("wernéritisation") can frequently be traced. The ferro-magnesian silicates are represented by many varieties of augite (sahlite, diopside, and ægerine), of enstatite (bronzite and hypersthene), and more rarely of hornblende. Garnets are a frequent and abundant constituent in many of these rocks, which in their accessory minerals and their structures often exhibit many features of striking interest. By the gradual disappearance of the feldspars from these rocks, they pass into remarkable varieties of pyroxenites and amphibolites. The chief varieties of these rocks, which are now described from Burma, are the following: Augite-gneiss (with sahlite, green diopside, etc.), augite-granulites (very rich in garnet), enstatite-gneiss (with bronzite or hypersthene), enstatite-granulites (rich in garnet), scapolite-gneisses, scapolite-granulites, pyroxenites and amphibolites of many varieties, and lapis-lazuli (lazurite-diopside-epidote rock). Many of these rocks contain crystals of calcite scattered through them.

It is with these basic rocks, and more especially with the ultra-basic types last mentioned, that the remarkable crystalline limestones that contain the rubies and spinels are most intimately

associated; indeed the passage of rocks consisting of various silicates with a few calcite crystals into masses principally composed of calcite, but with the silicate minerals and oxides dispersed through them, is of the most insensible kind. Some of the ruby-bearing limestones are highly micaceous ("cipollinos"), others are "calciphyres," in some of which the individual calcite crystals attain enormous dimensions. With the rubies and spinels are found a great number of oxides and silicates, both original and secondary, with much graphite and pyrrhotite.

In the gravels and clays of the district fine specimens of the minerals derived from the atmospheric degradation of the limestones and other rocks are found, sometimes broken and waterworn, at other times almost uninjured.

The study of the extensive series of minerals brought from the ruby mines of Burma is calculated to throw light upon many important scientific problems.

The association of minerals in the remarkable crystalline limestones of Burma is worthy of the most careful consideration. Corundum—in its various forms of ruby, sapphire, white sapphire, oriental amethyst, oriental topaz, etc.—is found associated with red, purple, brown, black and other spinels, the relative proportions of the minerals composed of aluminium oxide and of magnesium aluminate being very variable. The other minerals present in the crystalline limestones are zircon (rare); garnets (abundant in some places); a remarkable blue apatite; feldspars, of many species and varieties (including murchisonite, moonstone, sunstone, etc.), and in every stage of alteration; quartz (in many varieties, and exhibiting some remarkable peculiarities of crystallization); micas (phlogopite, fuchsite, with muscovite and other secondary and so-called hydromicas); hornblende and arfvedsonite; augite (sahlite, diopside, and ægyrine); enstatite (bronzite and hypersthene); wollastonite; lapis-lazuli; fibrolite; scapolite; with graphite and pyrrhotite. In addition to muscovite and other secondary micas, we find the following alteration products: Diaspore, margarite, and other clintonites, chlorites, vermiculites, and carbonates.

It is a noteworthy circumstance that none of the silicates combined with fluorine and boron compounds—such as topaz, tourmaline, chondrodite and humite, axinite, or datholite have been certainly detected in these limestones. Beryl (aquamarine) and danburite have been said to occur in the ruby earths, but there is reason for doubting the correctness of the statement. The limestone which, in the association of minerals found in it, most closely resembles the rock of Burma, is the remarkable white limestone of Orange County, N. Y., and Sussex County, N. J.; but in the American rock the corundum and spinels are associated with tourmalines and chondrodites.

In considering the question of the *origin* of the corundums and spinels of Burma, there are several very important facts to be borne in mind. The gems, when found *in situ*, always appear to

occur in the limestone, and this limestone is of a very remarkable character. There are no facts which point to the conclusion that the limestone was originally of organic origin, but many circumstances suggest that it may have been formed by purely chemical processes going on at great depths within the earth's crust. The highly-crystalline calcareous rock, besides containing so many silicates and oxides, is associated in the most intimate manner with pyroxene-gneisses and granulites containing anorthite, and with various pyroxenites and amphibolites. The lime feldspars and lime-soda feldspars of these rocks show the greatest tendency to undergo change—passing into scapolites by the process known as "werneritisation," and eventually giving rise to the separation of calcium carbonate and hydrated aluminium silicates. That from the last-mentioned salts the hydrated oxides of aluminium (diaspore, gibbsite, bauxite, etc.) may be separated has been shown by the studies of Liebrich and others, while the conversion of these substances into the anhydrous aluminium oxide has been shown to take place by H. St. Claire Deville, Stanislas Meunier, and others.

Crystallized aluminium oxide (corundum) has now been formed by chemists by no less than 20 different processes, and in some cases, like those described by Senarmont, Weinschenk, Bruhns, and Friedel, the formation and crystallization of the substance has been effected at very moderate temperatures under pressure. By one or other of these or similar methods it is probable that the formation of the Burma corundum and spinel has been effected, the source of the minerals being the decomposition products of basic and easily-altered lime feldspars in the pyroxene-gneisses.

Of still greater interest than the question of the origin of the corundums and spinels are the problems connected with the remarkable changes that these minerals undergo in deep-seated rock masses. The rubies of Burma, when found *in situ* in the limestones, are usually seen to be enveloped in a mass of materials produced by the alteration of their superficial portions. Nearest to the unaltered gem is a zone of diaspore—the hydrated aluminium oxide—and this is found to pass insensibly into various hydrous aluminous silicates—margarites and other clintonites, vermiculites, muscovites, kaolinites, etc. While, in some instances, the corrosion of the rubies appears to have gone on in a seemingly irregular manner, in the majority of cases a very definite mode of metamorphosis may be detected by the study of the various examples. There are evidently certain planes of "chemical weakness" (analogous to the cleavage planes, gliding planes, and other directions of physical weakness) along which decomposition goes on most readily. The principal of these solution planes is the basal plane, and parallel to it we find the gems eaten away in a series of step-like surfaces. Other less pronounced planes of chemical weakness exist parallel to the prism faces. Unaltered corundum is, like quartz, destitute of true cleavage,

and breaks with a perfectly conchoidal fracture. If, however, gliding planes and lamellar twinning be developed in corundum (like those so easily produced in the same way in calcite), parallel to the fundamental rhombohedron of the crystals, then these gliding planes become "solution planes," along which chemical action takes place most readily. Along the primary or secondary solution planes, hydration of the aluminium oxide takes place, and diaspore is formed, as shown by Lawrence Smith and Genth, and this unstable mineral enters into combination with silica and other oxides present to give rise to the numerous pseudomorphs of corundum, which are so well known to mineralogists.

There are certain crystals of corundum and spinel from Burma which present illustrations of corrosion of a very remarkable and interesting character. Commencing with the formation of naturally etched figures ("Verwitterungsfiguren"), the work of corrosion goes on till the whole crystal is broken up into an aggregate of simple forms—these being, in the case of the spinel, the octahedron, and, in the case of the corundum, a combination of the rhombohedron, basal plane, and prism.

It is interesting to note that the quartz, feldspars, and other minerals associated with the rubies and spinels of Burma, exhibit phenomena of external etching and internal chemical change similar to those we have been describing in the case of the gems. The study of the whole of the phenomena throws much new light on the remarkable changes which take place, at great depth in the earth's crust, in minerals which, at the surface, appear to be of a very stable character."—*Proc. Roy. Soc.*, No. 345.

9. *Brief notices of some recently described Minerals.*—ASCHARITE is a hydrous magnesium borate found in white lumps associated with boracite in the rock salt of Schmidtmannshall near Aschersleben. Specific gravity 1·85–1·95. The mean of three analyses gave:

B_2O_3 49·2 MgO 42·8 H_2O 8·0=100.

Described by W. Feit, see *Zeitschr. Kryst.*, xxiv, 625, 1894.

CUPROIODARGYRITE is an iodide of copper and silver, CuI. AgI, described by H. Schulze from Huantajaya near Iquique, Peru, where it occurs as a decomposition product of stromeyerite. It is found as an incrustation or filling crevices in limestone. Color sulphur-yellow; translucent. An analysis gave:

I 57·75 Ag 25·58 Cu 15·91=99·24.

—*Zeitschr. Kryst.*, xxiv, 626, 1895.

HOEFERITE is a hydrated ferric silicate closely related to chloropal; it is described by F. Katzer from Kritz near Rakonitz, Bohemia. It is amorphous, either earthy, granular or scaly and of a bright green color; hardness 1–3; specific gravity 2·34. An analysis gave:

SiO_2 36·14 Fe_2O_3 45·26 Al_2O_3 1·11 ignition 18·15=100·66.

This yields the formula $2Fe_2O_3 . 4SiO_2 . 7H_2O$.—*Min. petr. Mitth.*, xiv, 519, 1895.

KAMAREZITE, described by K. Busz, is a hydrated copper sulphate from Laurion, Greece. It occurs in crystalline masses, showing minute tabular crystals. Hardness 3; specific gravity 3·98; color grass-green. An analysis gave:

SO_3 17·52 CuO 51·50 FeO 0·69 H_2O 30·29 = 100.

Formula calculated $(CuOH)_2\ SO_4 . Cu(OH)_2 + 6H_2O$. — *Jahrb. Min.*, i, 115, 1895.

LOSSENITE is another mineral from Laurion, Greece, for which the complex formula $2PbSO_4 . 3(FeOH)_3As_2O_5 + 12H_2O$ is deduced by L. Milch. It occurs in acute pyramidal crystals related to scorodite in form and of a brownish red color. An analysis gave:

A_2O_5	SO_3	PbO	Fe_2O_3	H_2O (comb.)	H_2O	SiO_2	$CaCO_3$
33·44	3·74	10·63	34·53	3·74	11·81	1·13	1·46=100·48.

—*Zeitschr. Kryst.*, xxiv, 100, 1894.

LEWISITE, described by E. Hussak and G. T. Prior, is a mineral from the cinnabar mine of Tripuhy, Ouro Preto, Brazil. It occurs in minute regular octahedrons of a honey-yellow to colophony-brown color. Hardness 5·5; specific gravity=4·95. The composition is expressed by the formula $5CaO . 2TiO_2 . 3Sb_2O_5$, which was deduced from the analysis:

Sb_2O_5	TiO_2	CaO	FeO	MnO	Na_2O
67·52	11·35	15·93	4·55	0·38	0·99=100·72.

—*Mineral Magazine*, xi, 80, 1895.

MAUZELIITE is another titano-antimonate of calcium related to lewisite and described a little earlier by H. Sjögren. It is also found in isometric octahedrons of a dark brown color. Hardness 6–6·5, specific gravity 5·11. The mean of two analysis by R. Mauzelius gave:

Sb_2O_5	TiO_2	PbO	FeO	MnO	CaO	MgO	K_2O	Na_2O	F	H_2O
59·25	7·93	6·79	0·79	1·27	17·97	0·11	0·22	2·70	[3·63]	0·87=101·53.

It occurs with svabite and calcite at Jakobsberg, Sweden.—*Geol. För. Förh.*, xvii, 313, 1895.

TILASITE is a mineral related to adelite but containing fluorine; it is described by H. Sjögren from Långban, Sweden. It is found in granular masses of a gray color and resinous luster. Specific gravity 3·28. The composition is $(CaF)\ MgAsO_4$ deduced from the analysis by Mauzelius:

As_2O_5	P_2O_5	FeO	MnO	CaO	MgO	Na_2O	H_2O	F	Cl
50·91	*tr.*	0·14	0·16	25·32	18·22	0·29	0·28	8·24	0·02=103·58.

—*Geol. För. Förh.*, xvii, 291, 1895.

ZIRKELITE is a rare zirconium mineral described by E. Hussak and G. T. Prior from the locality Jacupiranga in Brazil, which has afforded the new species baddeleyite (ZrO_2), also perovskite, etc. It occurs in regular octahedrons of a black color. Hardness 5·5; specific gravity 4·706. An analysis gave:

ZrO_2, TiO_2	FeO	CaO	MgO	ign.
79·79	6·64	11·61	0·49	1·02 = 99·55

—*Mineral Magazine*, xi, 86, 1895.

TIFFANYITE.—This name has been given by G. F. Kunz to a hydrocarbon assumed to be present in certain diamonds, which on this account, as it is believed, exhibit marked fluorescence and phosphorescence. These optical phenomena are shown to belong only to a limited number of diamonds and not to be as general as has been supposed.—*Trans. N. Y. Acad. Sci.*, xiv, 260, 1895.

III. BOTANY.

1. *Pleiotaxy in the androecium of Epidendrum cochleatum, L.*—Mr. Theodore L. Mead has sent to the Harvard Botanical museum, from Oviedo, Florida, a strong plant of this species, which exhibits an anomaly in the number of anthers. Most of the flowers are well-developed and, at first sight, would not attract attention as being at all different from the type. But Mr. Mead had observed that even the most nearly normal flowers on this plant have three anthers. In most of the flowers, the three pollinia are about equal in size, but the two lateral ones are a little distorted by the curvature of the column. The anther normally present in this group of orchids is of ordinary shape and size, and plainly belongs to the outer whorl. The two extra stamens, which flank it, appear, as far as examination has yet gone, to belong, as might be expected, to the same whorl. Altogether the case is interesting, although it is one of a class of monstrosities rather common in the orchid family. It does not appear that anyone previous to Mr. Mead has observed the present deviation from the normal number in any plants of this species, although Clos has made a note of the occurence of three fertile anthers in an unnamed species of *Epidendrum*.

Among other deviations in this genus may be mentioned the following recorded by Penzig, who states that Magnus has seen in this species trimerous peloria with labelliform petals, and also dimerous zygomorphic flowers having transverse sepals. *Epidendrum articulatum* has been observed with an inflorescence of the year before. Other species in this genus have also exhibited striking peculiarities in individual cases, but perhaps the deviations have not been more numerous than in allied genera. G. L. G.

2. *The Structure and Development of the Mosses and Ferns;* by DOUGLAS HOUGHTON CAMPBELL, pp. 544, 8°, fig. 266. (Macmillan & Co.)—This treatise on the Archegoniatæ has been admirably planned and executed by Prof. Campbell. We have had many books and monographs giving the details of the structure of the different orders of Archegoniatæ and not a small number of papers devoted to a consideration of their homologies and phyllogeny. We have not had, however, in recent years, a connected account of the subject by one who, while master of

details, was also able to show their general bearing without indulging in excessive speculation. The contributions of Prof. Campbell to the study of the development of higher cryptogams have been numerous and important. In the present work his large practical knowledge of the different orders and his wide reading have enabled him to give an admirable summary of the present state of our knowledge with regard to the group of plants which, perhaps, above all others, are most important from a phyllogenetic point of view. The book is by no means a mere summary, but includes a large number of original observations, the more important because they relate to imperfectly known species of this country, and the illustrations are refreshingly original and not the time-worn cuts which seemed destined to be copied in all books, even those by experts.

The proportions of the book are good, for the author has laid more stress on typical structures than on specific details. Hence we find about twice as many pages devoted to the Hepaticæ, in which there are several marked types of reproduction, as to the Musci, in which generic and specific differences are the prominent features. Furthermore, for purposes of phyllogenetic study, the Hepaticæ are, in the opinion of most modern writers, more significant than Musci. We think that Prof. Campbell did well not to offer a long introduction, but has made the subject clearer by first giving a condensed account of each order and then expanding the account of the suborders. If we congratulate Prof. Campbell on what he has given us, we can also thank him for what he has not given us. The terminology is simple and clear, and he has not attempted to force upon us a new series of names of different organs and structures to express what was sufficiently well expressed before. Nor has he indulged in hair-splitting theoretical discussions, the summary and conclusions being limited to ten pages. The book cannot be said to be easy reading; it is so full of facts that one must read slowly, and, in a short review, one can hardly refer to details. We have noticed but one statement which seems to us incorrect. On p. 40 it is said that *Ricciocarpus natans* fruits only when growing upon the earth. In eastern New England it fruits abundantly when floating. W. G. F.

3. *Phycotheca Boreali-Americana;* by F. S. Collins, Isaac Holden and W. A. Setchell.—We are glad to notice the appearance in rapid succession of the first three fascicles of this valuable collection of North American algæ. In form they resemble the fascicles of the Phycotheca Generalis of Hauck and Richter, each fascicle containing fifty species bound in folio. The specimens are in excellent condition and well mounted and the determinations of the species have been made with care and accuracy, the labels being clear and full. The algæ represented in the series include species from fresh water as well as marine and were collected in part in the West Indies and on the Pacific coast, although the larger part are from the Northeastern States, where the three botanists under whose supervision the Phyco-

theca is prepared, have made special studies of the flora. Among the many interesting species of this collection we may mention the numerous Cyanophyceæ, several of which had not been recorded previously in North America and which have formed the subject of Prof. Setchell's paper, Notes on some Cyanophyceæ of New England, in the October number of the Bulletin of the Torrey Botanical Club. The Chlorophyceæ, Phæophyceæ and Rhodophyceæ are represented by a number of interesting species. Among the West Indian forms are the rare and imperfectly known *Liagora decussata* Mont., collected in Jamaica by Miss Pease, and the curious *Hormothamnion enteromorphoides* Grunow, collected in Jamaica by Dr. Humphrey. The Phycotheca will prove an indispensable aid to phycologists, valuable not only from the excellence of the specimens but also from the careful determination of the species. W. G. F.

4. *An Introduction to the Study of Seaweeds:* by GEORGE MURRAY. Pp. 271, 8°, fig. 88, pl. 8. (Macmillan & Co.)—It is a long time since there has appeared any general introduction to the study of marine algæ, and the student has been forced to depend upon the common botanical text-books, in which the marine algæ are generally treated very inadequately in a few pages. Recent investigations on the structure and development of seaweeds have been numerous and important, quite overturning our former views on their classification, but the results scattered through numerous journals in several languages have not hitherto been brought together in a way to be easily accessible. The excellent book by George Murray, now in charge of the botanical department of the British Museum, will be of very great service to all interested in marine algæ. In the Introduction, the most readable chapter of the book, the writer gives an admirable account of the general habits and distribution of marine vegetation, a subject on which he is specially competent to speak. There then follows a classified list of works valuable for reference. The main body of the book is devoted to an account of the three sub-classes, *Phæophyceæ*, *Chlorophyceæ* and *Rhodophyceæ*, taken up in the order named. There are also short chapters on the *Diatomaceæ* and *Cyanophyceæ*. The pages are so crammed with facts that the book is almost encyclopædic. We have here for the first time a careful collation of what has been observed in relation to the different orders up to the present time, but the writer is careful not to confound observations with purely theoretical conclusions, and is content with a statement of opposing theoretical views without feeling obliged in all cases to decide in favor of either in the present state of our knowledge. The chapters on *Phæophyceæ* and *Rhodophyceæ* will be especially appreciated by all who have to teach or lecture upon these two large and perplexing groups. The illustrations, selected from numerous monographs and special papers, are generally well executed, but we do not think that the colored plates are quite satisfactory, although, perhaps, they are as good as the low price of the book would warrant. W. G. F.

IV. Miscellaneous Scientific Intelligence.

1. *Comet of 1843 I.*—Herr Kreutz of Kiel has been engaged in the investigation of the path of the great comet 1843 I, which has seemed to bear close relations to, if not identity with, the comets of 1668, 1880 I, and 1882 II. In the *Astronomische Nachrichten*, No. 3320, he gives in advance of full publication the principal results of his computations. The most probable period of revolution is 512·39 ± 70·75 years. The period of 36 years, necessary if there is identity with comet 1880 I, as well as that of 175 years if there is identity with comet 1668, are found to be inconsistent with the observations of comet 1843 I. He finds, however, that while a parabolic orbit is inadmissible, a period of 800 years, equal to that of the great comet 1882 II, is admissible. Moreover, he finds a remarkable relation, viz : that the line of intersection of the planes of the two orbits is for each of them along the major axis of the orbit. Hence he concludes with considerable probability, 1st, that the two comets are parts of one original comet, and 2d, that the separation took place in some past epoch at or near the perihelion passage of the original body. Why it may not have separated near aphelion is apparently not considered.

2. *Harvard College Observatory.*—The Director of the Observatory of Harvard College, Professor E. C. Pickering, has recently commenced the publication of a series of Circulars, designed to furnish a prompter announcement than has hitherto been possible of the results of the Observatory work. Numbers 1, 2 and 3 have already appeared. The first describes a new star which appeared in the spring of 1895 in the constellation Carina, discovered from an examination of the Draper Memorial photographs taken at the Arequipa Station. The spectrum of the star resembles closely those of Nova Aurigæ and Nova Normæ. Circular No. 2 describes certain variable star clusters.

Circular No. 3 (Dec. 13) gives observations of a new variable star of the Algol type. This is the star B. D. +17° 4367, magn. 9·1, whose approximate position for 1900 is in R. A. $20^h\ 33^m.1$, Decl. +17° 56′. The change of brightness appears to be rapid and the range of variation to be large, exceeding two magnitudes.

3. *Distribution of the Magnetic Declination in Alaska and adjacent waters for the year* 1895, with a chart, by C. A. Schott. (U. S. Coast and Geodetic Survey, Bulletin No. 34.)—This brief pamphlet, in addition to the new and excellent declination chart for Alaska, discusses briefly the observations available and the methods by which they have been reduced for use in laying down the isogonic lines.

4. *Geodesy, Determinations of Latitude*, gravity and magnetic elements at stations in the Hawaiian Islands, including a result for the mean density of the earth. 1891, 1892, by E. D. Preston. (U. S. Coast and Geodetic Survey, W. W. Duffield, Supt. Appen-

dix No. 12.—Report for 1893, pt. 2, pp. 513–639, plates 22–37.) Washington, 1894. In this report the mean density of the earth is calculated from observations of the force of gravity at two stations (Waiau and Kawaihae) on the Island of Hawaii in comparison with the density of Mauna Kea, determined from specimens whose specific gravity was measured by G. P. Merrill of the Smithsonian Institution and E. S. Dana (this Journal, vol. xxxvii, p. 442 and 447) to be in relation to the density of the mountains as 1·77 to 1, the density of the mountain being assumed to be 2·90; this gives mean density of the earth = 5·13.

5. *Relative Schwerebestimmungen durch Pendelbeobachtungen:* ausgeführt durch die K. und K. Kriegs-marine in den Jahren 1892–1894. 630 pp. with 5 plates.—The results of a long series of pendulum observations carried through by the Austrian Government between the years 1892 and 1894 are here presented in full tabular form with explanations as to the instruments employed, etc. The stations occupied include a large number on both east and west shores of the Adriatic sea and a series of others at widely separated points distributed over the world at large.

6. *Elementary Physical Geography*, by RALPH S. TARR. 488 pp. 8vo. New York and London, 1895. (Macmillan & Co.)—The author has given here a clear and interesting presentation of the various topics commonly included under the general head of Physical Geography. So many different branches of science have to be touched upon that in an elementary work like the one in hand, the treatment is of necessity often superficial. In the main, however, good judgment is used in the choice of matter and the work as a whole will be found a highly valuable contribution to the available text-books in a field not before well occupied. In the matter of illustrations the author has shown commendable enterprise; they are numerous, well selected from many sources and with few exceptions very satisfactorily reproduced.

7. *The Herschels and Modern Astronomy;* by AGNES M. CLERKE, New York, pp. 224, 12mo, 1895. (Macmillan & Co.) Century Science Series, vol. iii.—The life of John Herschel has never been written, and the wonderful series of papers which the elder Herschel contributed through a series of years to the Philosophical Magazine have never been collected and republished, yet the lives and works of both are so well known that the present volume offers little that is new; nevertheless, being written by Miss Clerke, it will prove both interesting and profitable to laymen and specialists alike. W. B.

8. *Justus von Liebig, His Life and Work;* by W. A. SHENSTONE, pp. 219. (Macmillan & Co., $1.25.)—More than twenty years after Liebig's death, this essay appears as the first comprehensive and popular account of his scientific career. The author justly considers the subject of his work as one of the greatest men of this or, perhaps, any other century. He was the pioneer in four great departures in science, in organic chemistry, in the application of chemistry to agriculture and to

physiology, and in the development of the laboratory method of teaching. The book gives an excellent account of Liebig's work, most of which was important in its practical application and of great general interest, and being nearly free from technicalities, the essay is available for the general reader. H. L. W.

9. *Bibliotheca Zoologica II.*—Verzeichniss der Schriften über Zoologie welche in den periodischen Werken enthalten und vom Jahre 1861–1880 selbstständig erschienen sind, etc. Bearbeitet von Dr. O. TASCHENBERG. 13te Lieferung, pp. 3889–4208. Leipzig, 1895. (Wm. Engelmann.) The present thirteenth part of this great work is the last one, as announced in the prospectus. It includes signatures 481 to 520, or pages 3889 to 4208. The appearance of the earlier parts has been repeatedly announced in this Journal and attention has been called to the careful accuracy and thoroughness which characterize their preparation. The editor may well be congratulated upon the completion of his labors.

10. *Zoologisches Adressbuch:* Namen und Adressen der lebenden Zoologen, Anatomen. Physiologen und Zoopaleontologen sowie der künsterlischen und technischen Hülfs-Kräfte; herausgegeben im Auftrage der Deutschen Zoologischen Gesellschaft von R. Friedländer und Sohn, 8vo, 740 pp. Berlin, 1875.

This is a highly useful work, giving, as mentioned in the title quoted above, the names and addresses of living zoologists, in their different departments. The names are arranged geographically, all the members of the faculty at a single university being printed together and the whole presented with commendable clearness of typography. A full index at the end of the volume repeats the names, grouped under the special branches of the general science. The work cannot but be found most convenient by all in this department.

11. *New York Academy of Sciences.*—The following geological papers appear in the recently issued volume xiv of the New York Academy:

Dislocations in certain portions of the Atlantic coastal plain strata and their probable causes, by ARTHUR HOLLECK, pp. 8–20, figs. 1–5.

On a granite-diorite near Harrison, Westchester County, N. Y., by HEINRICH RIES, pp. 80–86.

The Protolenus fauna, by G. F. MATTHEW, pp 101–153, plates i–vi.

The effusive aud dyke rocks near St John, N. B., by W. D. MATTHEW, pp. 187–218, plates xii–xvii.

Two new Cambrian graptolites with notes on other species of Graptolitidæ of that age, by G. F. MATTHEW, pp. 262–273.

The geological section of the East River, at Seventieth street, New York, by J. F. KEMP, pp. 273–276.

12. *Ostwald's Klassiker der Exakten Wissenschaften.*—The following list gives the recent additions to this valuable series of scientific classics:

No. 60. Die Geometrischen Constructionen, ausgeführt mittelst der Geraden Linie und eines festen Kreises, als Lehrgegenstand auf höheren Unterrichtsanstalten und zur praktischen Benutzung von Jacob Steiner (1833).

No. 61. Ein Versuch die Mathematische Analysis auf die Theorien der Elektricität und der Magnetismus anzuwenden von George Green (1828).

No. 62. Sechs pflanzenphysiologische Abhandlungen von Thomas Andrew Knight (1803–1812).

No. 63. Zur Entdeckung des Elektromagnetismus. Abhandlungen von Hans Christian Oersted und Thomas Johann Seebeck, (1820–1821).

No. 64. Ueber die Vierfach Periodischen Functionen zweier Variabeln von C. G. J. Jacobi, (1834).

No. 65. Abhandlung über die Functionen zweier Variabler mit vier Perioden, von Georg Rosenhain, (1851).

No. 66. Die Anfänge des Natürlichen Systemes der chemischen Elemente, Abhandlungen von J. W. Doebereiner und Max Pettenkofer, (1829, 1850).

Obituary.

George Lawson, Professor in Dalhousie College, Halifax, Nova Scotia, died at his home on the evening of November 10. He was born in Scotland, Oct. 12, 1827. He was educated at a private school. After a few years of study by himself, in which he devoted a good deal of attention to law, he entered the University of Edinburgh, and at once began active work in Natural Science, giving much of his time to Botany. He was, for a time, Curator of the Herbarium at the University and assistant to the Professor of Botany. In 1857 he took the degree of Ph.D. at the University of Giessen, and in the following year came to Canada as professor of chemistry and natural history in Queen's University, Kingston, Ontario. In 1863 he accepted the professorship of chemistry and natural history in Dalhousie College. From the first year of his residence in Nova Scotia he engaged in the development of the agriculture of the Province, and was the secretary of the Board of Agriculture till 1885. In that year the work of the board was transferred to the provincial government and Dr. Lawson became Secretary of Agriculture for the Province.

His contributions to science have been published chiefly in the Transactions of the Botanical Society of Edinburgh, the Royal Society of Canada, and the Nova Scotia Institute of Science. His activity in bringing before the farmers of the province the latest and most trustworthy intelligence in agricultural matters was unabated up to the last of his life. Professor Lawson was a member of many learned societies in America and Europe, and was for a time President of the Royal Society of Canada. G. L. G.

M. S. Bebb.—At the moment of going to press, we learn that M. S. Bebb, of Rockford, Illinois, died in California, on the 5th of December. Although for some years in enfeebled health, he did not relinquish until recently the study of his favorite plants, the willows. We hope to give in a subsequent number of this journal some account of the useful life of this botanist, who has endeared himself to his correspondents everywhere. G. L. G.

Don Antonio del Castillo, founder and director of the Geological Survey of Mexico, died on the 27th day of October, 1895, in the city of Mexico.

BOOKS AND PAMPHLETS RECENTLY RECEIVED AND THUS FAR NOT OTHERWISE NOTICED.

Notes on the Nebular Theory in relation to stellar, solar, planetary, cometary and geological phenomena, by William Ford Stanley, F.R.A.S, etc. London, 1895, 259 pp. 8vo. (Kegan Paul, French, Trübner & Co.)

Laboratory Course of Elementary Physics, by W. J. Loudon and J. C. McLennan. 302 pp. 8vo. New York and London (Macmillan & Co.).

Resultate der im Sommer 1893 im dem nördlichsten Theile Norwegens ausgeführten Pendelbeobachtungen nebst einer Untersuchung über den Einfluss von Bodenerschütterungen auf die Schwingungszeit eines Pendels, von O. E. Schiötz. 8vo, 42 pp. Kristiania, 1894 (Die Norwegische Commission der Europäischen Gradmessung).

Ueber die Auswahl der Punkte bei Göttingen, an welchen bei Probe-Pendelmessungen Differenzen in der Intensität der Schwere zu erwarten waren, von A. von Koenen, und Ueber die Ergebnisse der ersten Pendelmessungen, von W. Schur (Nachr. d. K. Gesells. Wissensch. zu Göttingen. Math.-Phys. Klasse, 1895. Hft. 2, pp. 1–7).

Astronomische Arbeiten der österreichischen Gradmessungs-Commission. Bestimmung der Polhöhe und des Azimutes auf den stationen Spieglitzer Schneeberg, Hoher Schneeberg und Wětrnik; ausgeführt von Professor Dr. Josef Herr. Nach dessen Tode definitiv gerechnet und herausgegeben von Professor Dr. Wilhelm Tinter. 96 pp. 4to. Vienna, 1895.

Recent Bulletins of the U. S. Geological Survey:

No. 118. A Geographic Dictionary of New Jersey, by Henry Gannett. 8vo, 131 pp.

No. 119. A Geological Reconnaissance in Northwest Wyoming, by George H. Eldridge. 8vo, 72 pp.

No. 120. The Devonian System of Eastern Pennsylvania and New York, by Charles S. Prosser. 8vo, 81 pp.

No. 121. A Bibliography of North American Paleontology, 1888–1892, by Charles R. Keyes. 8vo, 251 pp.

No. 122. Results of Primary Triangulation, by Henry Gannett. 8vo, 412 pp.

Missouri Geological Survey, vol. viii, Annual Report for 1894, by Charles R. Keyes, State Geologist, with accompanying papers. 405 pp. 8vo. Jefferson City, 1895.

Geological Survey of Canada. Several series of maps have recently been issued by the Canadian Survey; nine of these are devoted to the auriferous creeks of the Cariboo district, British Columbia; fourteen others belong to Nova Scotia.

Le système dévonien dans la chaîne des Mougodjares par P. Vénukoff, pp. 103–158, plates i–iii. St. Petersburg, 1895.

The Cretaceous Foraminifera of New Jersey, by R. M. Bagg.

Mount Shasta a typical volcano, by J. S. Diller. National Geographic Monographs, vol. i, No. 8, pp. 237–268, figures 1–7 (Am. Book Co.). 1895.

On Bryozoa.—Two contributions to the nomenclature and elaboration of the structure of Bryozoa and Corals are made by Geo. B. Stimpson of the State Museum in the Report of the State Geologist of New York for the year 1893. The titles are Glossary and Explanation of specific names of Bryozoa and Corals described in vol. vi. Paleontol. of New York and other reports, pp. 731–747, and a discussion of the different genera of Fenestellidæ, pp. 687–727.

L'eruzione del Vesuvis nel mese de Luglio del 1895, Pasquale Franco ed Agostino Galdieri, pp. 1–11. Napoli, 1895.

Geological Survey of Alabama, Report upon the Coosa Coal field with sections, by A. M. Gibson, Assist. Geologist, pp. 1–143. Montgomery, 1895.

Sur la Geologie der Congo Français par M. Maurice Barret (Extrait der Ann. des Mines), pp. 1–132, plates i–xiv. Paris, 1895.

Ueber die Silurformation in Jemtland von Carl Wiman (Reprinted from Bull. Geol. Instit. Upsala, No. 2, vol. i, 1893), pp. 1–21.

Republication of descriptions of fossils from the Hall Collection in the American Museum of Natural History, from the Report of progress for 1861 of the Geological Survey of Wisconsin, by James Hall, with illustrations from the

original type specimens not heretofore figured, by R. P. WHITFIELD, Mem. Am. Mus. Nat. Hist., vol. i, Part II, pp. 39–74, plates iv–xii, Aug. 10, 1895.

On the Organic remains of the Little River Group, Nos. II and III, by G. F. MATTHEW, Trans. Roy. Soc. Canada, IV, 1894, pp. 89–111, plate i.

Ueber der Entwicklung von Dadocrinus gracilis v Buch und Holocrinus Wagneri Ben. und ihr Verwandtschaft mit anderen Crinoiden, von A. VON KOENEN (Nachr. der K. Gesellschaft der Wissenschiften zu Göttingen, Math Phys. Klasse. 1895, Heft 3), 11 pp. Göttingen, 1895.

Ueber einige Fischreste der Norddeuschen und böhmischen Devons, von A. VON KOENEN (Abhand. k. Gesellsch. d. Wissensch. zu Göttingen. Bd. xl, pp. 1–37, plates i–v). Göttingen, 1895.

Boletin de la Comision geológica de México, Num. 1. Fauna Fosil de la Sierra de Catorce, San Luis Potosi, por Antonio del Castillo, Director, y Jose G. Aquilera. Bajo los auspicios de Ministerio de Fomento. 4to, 55 pp. with xxiv plates. Mexico, 1895.

Lithia Hercynica, Verzeichnis der Minerale des Harzes und seines Vorlandes, von Erwin Schulze, Ph.D., 191 pp. Leipzig, 1895 (Veit & Comp.).

Annuaire Géologique universel, revue de Géologie et Paléontologie dirigeé par Dr. L. Carez et H. Douvillé avec le concours de nombreux géologues francais et étrangers; fondé par le Dr. Dagincourt. Anneé 1893, Tom. x, 4e. fascicule. Paris, 1895, pp. 677–900.

Expedicion científica al Popocatepetl. José G. Aquilera y Ezequiel Ordoñez. 8vo, 48 pp. Mexico, 1895. Comisión geológica Mexicana, Director A del Castillo.

The Onyx Marbles: their origin, composition and uses, both ancient and modern, by George P. Merrill. From the Report of the U. S. Nat. Museum, 1893. pp. 539–585, plates 1–18. Washington, 1895.

An examination into the Nature of Palæotrochis, by Charles H. White, Geol. Dept. Univ. of N. Carolina. Journal of the Elisha Mitchell Scientific Society, 1894, pp. 50–63.

The Soils of Texas: A preliminary statement and classification, by E. T. Dumble, State Geologist. (Texas Academy of Science, June 18, 1895.)

Notes in the Texas Tertiaries, by E. T. Dumble. (Texas Academy of Science, June 19, 1894.)

Determinaças das Posiçoes Geographicas de Rodeio, Entre-Rios, Juiz de Fóra, Joao Gomes e Barbacena, publicada por L. Cruls, Director do Observatorio do Rio de Janeiro. Rio de Janeiro, 1894.

Méthode Graphique pour la determination des heures approachées des Eclipses du Soleil et des Occultations par L. Cruls, Directeur de l' Observatoire. 8vo, 54 pp. Rio de Janeiro, 1894.

O Clima do Rio de Janeiro por L. Cruls, Director, etc. Segundo as observaçoes Meteorologicas feitas durante o periodo de 1851 a 1890. Rio de Janeiro, 1892 (Portuguese and French).

An Account of the Smithsonian Institution: its origin, history, object and achievements, Washington. 1895 (for distribution at the Atlanta Exposition). The Exhibit of the Smithsonian Institution at the Cotton States Exposition at Atlanta. Washington, 1895.

On the densities of oxygen and hydrogen and on the ratio of their atomic weights, by Edward W. Morley, Ph.D. 4to, 117 pp. Washington, 1895.—Smithsonian Contribution to Knowledge, No. 980 (vol. xxix).

Journal of the American Public Health Association. Published quarterly ($5 per annum) by the American Public Health Association at Concord, N. H.

The cause of warm and frigid periods, by C. A. M. Taber. 12mo, 80 pp. Boston, 1894.

Michigan State Agricultural College Experiment Station: Farm Department. 127, Dairy records; 128, Fattering lambs. 1895.

The Beginning of Agriculture, by W. J. McGee. From the American Anthropologist, October, 1895, pp. 350–375.